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# **Remedial Investigation Granite City Site Granite City, Illinois**

NL Industries, Inc.  
Hightstown, New Jersey

September 1988



**O'BRIEN & GERE**

REPORT

REMEDIAL INVESTIGATION  
GRANITE CITY SITE  
GRANITE CITY, ILLINOIS

SEPTEMBER, 1988

PREPARED BY:

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## EXECUTIVE SUMMARY

The Granite City Site (Site) is the location of a former secondary lead smelting facility. Metal refining, fabricating, and associated activities have been conducted at the Site since before the turn of the century with secondary lead smelting conducted since 1903. NL Industries entered into an Agreement and Administrative Order by Consent with the USEPA and IEPA in 1985 to implement a Remedial Investigation and Feasibility Study. This Remedial Investigation Report presents the results of the field investigations as well as an evaluation of the effect of the field conditions on human health and the environment. This Executive Summary presents a brief overview of the findings, presented in detail within the body of the Remedial Investigation Report.

### Site Features Investigation

The Site is located within a heavily industrialized section of Granite City, Illinois, a community of approximately 40,000 people across the Mississippi River from St. Louis, Missouri. The Site is located within the Mississippi River Valley, however, it is not within the 100 year flood plain of any surface water. The area receives approximately 35 inches of precipitation annually with an average pH of wet deposition of approximately 4.4 Standard Units (S.U.).

### Hydrogeologic Investigation

The Site is underlain to a depth of approximately 100 feet by alluvial, glaciofluvial, and glaciolacustrine deposits, which become progressively coarser with depth. Recharge to ground water within the

area is from precipitation and induced infiltration of surface water from the Mississippi River and other surface water bodies in the area. Water within the unconsolidated deposits beneath Granite City is used for industrial and flood control purposes. No potable uses for the ground water were identified. The Granite City water system uses the Mississippi River as its water source.

Twelve wells were installed proximate to and on the site as part of a ground water investigation which began in October 1982. The ground water flows in a south-southwesterly direction towards the Mississippi River at a velocity ranging from  $2 \times 10^{-3}$  to 0.5 feet/day.

Ground water quality since 1982 has remained reasonably consistent. Lead concentrations observed in all wells have generally remained less than 0.02 mg/l, within the drinking water standards for lead. Background ground water quality in the shallow wells is characterized by dissolved solids ranging from 625 mg/l to 1000 mg/l, sulfates ranging from 165 mg/l to 320 mg/l, and a pH of 6.6. Of the metals analyzed, lead, iron, manganese, and cadmium were observed at concentrations exceeding the detection limits. Background ground water quality in the deeper wells is characterized by dissolved solids of 993 mg/l, an alkalinity of 430 mg/l as  $\text{CaCO}_3$ , sulfate of 288 mg/l, and a pH of 6.7 S.U. In addition the filterable manganese concentration was 0.99 mg/l. Accordingly, the ground water is not suitable for development as a potable supply due to concentrations of dissolved solids, sulfates, and manganese above values presented in 40 CFR 143.

Two wells located on the site demonstrate elevated concentrations, as compared to background, of sulfates, dissolved solids, arsenic, cadmium, manganese, nickel, and zinc. However, data from shallow

wells located at the hydraulically down gradient property boundary demonstrated water quality similar to that in the background monitoring well indicating that heavy metals are not migrating off the site in this zone. Comprehensive data on deep ground water quality is not available, however receptors have not been identified at this time and this evaluation may be incorporated in future investigations.

This lack of measurable migration of metals is explained by the high alkalinity of the ground water, the low solubility of metal carbonates, and cation exchange within the unconsolidated deposits. Evidence to support these mechanisms was provided in the 1983 studies conducted by the Illinois EPA.

#### Waste Pile Investigation

Located on the site is a pile composed primarily of blast furnace slag, and battery case material. The volume of the pile is approximately 85,000 cubic yards. In addition, smaller piles, which were associated with the adjacent St. Louis Lead Recycler's (SLLR) recycling operation, comprise approximately 6300 cubic yards. Tests conducted on the materials in the piles demonstrate lead concentrations in the range of 11-29% and 1-28% for the SLLR pile and slag pile, respectively. Test results demonstrate that the waste pile materials are a characteristic hazardous waste under 40 CFR 261.

#### Soils Investigation

Surface soil samples were collected from 52 locations, 50 of those, properties other than Taracorp or St. Louis Lead Recyclers. Generally samples were collected at depths of 0-3 and 3-6 inches below grade.

added

With the exception of one anomalous value approximately 3200 feet from the site boundary the results indicate that the lead concentration in surface soils within 1/4 mile of the site boundary were higher (514 - 9250 mg/kg) than those further from the site (200-500 mg/kg). Off-site surface samples typically contained more lead (average 1160 mg/kg) than the 3-6 inch samples (average 560 mg/kg). The on-site soil lead concentrations were 1150 mg/kg for the 0-3 inch sample and 48,300 mg/kg for the 3-6 inch sample. Leachate testing on a sample of the soil with an elevated lead concentration demonstrated that the lead in the sample tested was not extractable and that this material is not a characteristic hazardous waste under 40 CFR 261. Other metals tested in surface soil samples, cadmium, arsenic, chromium, and antimony, were present at 2% or less of the lead concentration in the zoned residential area east of the site. → what about the rest of the samples?

#### Surface Water Investigation

Surface water sources are not present on or near the Site. Studies conducted as part of the RI evaluated the characteristics of storm water runoff from the slag pile. This runoff contained concentrations of lead in the range of 3 to 40 mg/l. These concentrations are a function of lead-bearing particulates suspended in the runoff and solubilization of the lead due to the acidic precipitation in Granite City. Runoff from the slag pile either percolates to ground water or evaporates.

#### Air Investigation

The IEPA operates several air quality sampling stations in the vicinity of the Site and has generated data quarterly since 1978. The

data demonstrate that since 1984, air quality in Granite City has met standards for lead and is generally less than 25% of the applicable standard for lead.

#### Risk Assessment

The risk assessment evaluated exposures to lead under present conditions. The risk assessment evaluated human exposure to lead from inhalation, direct contact, soil ingestion and water ingestion.

→ According to the Center for Disease Control the observed soil lead concentrations in Granite City could cause an increase in blood lead  
→ concentration. However, the site specific quantitative risk assessment indicates no unacceptable impacts to human health from lead on the Site or in the surrounding community. This conclusion is supported by blood lead analyses conducted by the Illinois Department of Public Health during 1982.

#### Remedial Response Objectives

The present conditions indicate that, based on upper bound worst case assumptions, a person's blood lead level could approach concentrations identified by the EPA as levels for concern. A change in land use which would allow direct contact with or disturbances of the waste pile could pose an unacceptable risk in the future. Consequently, response objectives are presented based on upper bound worst case scenarios. The objectives address surface soil/waste pile lead concentrations and ground water quality and are based on potential applicable or relevant and appropriate requirements (ARARs). A response objective is presented for air to address the situation where a

remedial technology could increase the atmospheric concentration of lead due to waste pile disturbances and resultant suspension of lead particulates in air.

#### Preliminary Remedial Technologies

The universe of remedial technologies was defined and those technologies which appeared appropriate for the site were presented.

These technologies include:

- recycle/recovery
- solidification/fixation
- containment
- excavation and disposal?
- ground water collection/treatment

Development of and detailed evaluation of alternatives will be addressed in a Feasibility Study Report.

## SECTION 1 - INTRODUCTION

### 1.01 Site Background Information

The Granite City Site (Site) is the location of a former secondary lead smelting facility. As shown in Figure 1, the Site is located in Madison County, Illinois, at 16th Street and Cleveland Boulevard in Granite City. The area surrounding the site is primarily utilized by heavy industry. The Site is presently owned by Taracorp, Inc. (Taracorp) and is contiguous to properties owned by Trust 454, Terminal Railroad Associates, Inc., Illinois Central Gulf Railroad, Chicago and Northwestern Railroad, and Tri-Cities Trucking Inc. (TCT). St. Louis Lead Recyclers, Inc. is a tenant of Trust 454. Figure 2 presents these and other properties proximate to the Site.

Metal refining, fabricating, and associated activities have been conducted at the Site since before the turn of the century. Prior to 1903, the facilities at the Site included a shot tower, machine shop, factory for the manufacture of blackbird targets, sealing wax, manufacture of mixed metals, refining of drosses, and the rolling of sheet lead. Since 1903 facilities have been added to provide secondary smelting capabilities. Battery recycling facilities were installed in the 1950's.

A site map showing the facilities is presented as Figure 3. The secondary smelting operations produced a number of products, including sheet lead, solder, shotgun lead pellets, lead wool, lead pipe, powdered lead, and secondary lead ingots.

Figure 4 presents a process flow diagram for the facilities existing prior to February 1983. The major pieces of equipment involved in the secondary smelting activities included a blast furnace, a rotary furnace,

several lead melting kettles, a battery breaking operation, a natural gas-fired boiler, several baghouses, cyclones and an afterburner.

Historically, solid wastes generated by the manufacturing facilities were stored on-site in a slag storage area as shown in Figure 3. There are also reports that hard rubber from reclaimed battery cases were removed from the Site by area citizens and governmental authorities (Venice Township) for use as fill and alley paving material. Liquid wastes from the manufacturing operations are discharged via process sewers to the municipal sewer system. Granite City utilizes combined sewers running under the Site to transport wastewater to treatment facilities.

The Site was owned by the Hoyt Metal Company until 1903, when the United Lead Company purchased the property. NL Industries, Inc. (NL), formerly the National Lead Company, bought the Site in 1928. In August, 1979 NL sold the Site to Taracorp. Taracorp operated the secondary smelting operation until 1983, when it filed for protection from its creditors under Chapter 11 of the Federal Bankruptcy Code. Taracorp continues to operate the metal refining and fabricating facilities at the Site.

In June of 1981, SLLR began reclaiming operations with the waste pile on the Taracorp property. The day to day activities continued through June 1983. Supplemental recovery operations occurred during the fourth quarter of 1983. It has been estimated that, during this time period, 11,000 tons of the waste pile material were processed by SLLR. The reclaiming operations resulted in several small piles of non-recyclable materials (i.e., slag and hard rubber battery case material) to the southwest of Taracorp's waste pile. Analytical results

of samples obtained from the SLLR piles indicate that the materials in these piles are similar to those in the Taracorp waste pile, in that they contain elevated concentrations of lead and other heavy metals.

State and Federal regulatory agencies have had a series of contacts with the facility since the 1970's. Appendix A presents a summary of the regulatory response actions that were documented in files maintained by NL.

The Illinois Environmental Protection Agency (IEPA), pursuant to requirements of the Clean Air Act, completed the Illinois State Implementation Plan Volume 9 for lead in February, 1981. The area which included the Site was designated as a nonattainment area with respect to the National Ambient Air Quality Standard (NAAQS) for lead of 1.5 ug/m<sup>3</sup>. In response to elevated ambient air lead concentrations and the findings of the 1981 Report, the IEPA conducted a study on lead pollution in Granite City and two nearby areas, Madison and Venice. This study, published in April 1983, was concerned not only with ambient air lead concentrations, but also with lead concentrations in soil, garden vegetables and water. In addition, blood lead concentrations of residents living in the vicinity of the Site were evaluated, and a risk assessment was conducted. The findings of the study indicated that, although a major near term risk to public health did not likely exist, elevated soil lead concentrations observed near the Site were cause for concern (IEPA, 1983).

A State Implementation Plan - Granite City was published in September 1983 by the IEPA. The IEPA's 1983 Report indicated that the lead nonattainment problem was in large part attributable to emissions associated with operation of the secondary lead smelter and lead

reclamation activities conducted by SLLR. The IEPA therefore procured Administrative Orders by Consent with Taracorp, St. Louis Lead Recyclers, Inc., Stackorp, Inc., Tri-City Truck Plaza, Inc. and Trust 454 during March 1984. The orders specified the implementation of remedial activities relative to the air quality.

The U.S. Environmental Protection Agency (USEPA) determined that the Site was a CERCLA facility. Due to Taracorp's bankruptcy and NL's former ownership of the Site, NL voluntarily entered into an Agreement and Administrative Order by Consent (Consent Order) with the USEPA and IEPA in May 1985 to implement a Remedial Investigation and Feasibility Study (RI/FS) of the Site and other potentially affected areas. NL retained O'Brien & Gere Engineers, Inc. (O'Brien & Gere) in July 1985 to conduct the RI/FS in accordance with the Consent Order. O'Brien & Gere prepared a Work Plan which was approved by the Illinois EPA and US EPA (O'Brien & Gere, 1986).

#### 1.02 Nature and Extent of Problem

The nature of the problem on and near the Site is one of lead and other heavy metals in several environmental matrices. Lead concentrations have been observed in surface soils at on-site and off-site locations (IEPA, 1983). The off-site locations at which lead concentrations have been observed include properties surrounding the Site, and properties in Venice Township, south of the Site, where hard rubber from battery cases was utilized as fill material and/or paving material by private parties and Venice Township.

The waste pile on the Site contains slag, lead bearing fines in 55-gallon drums, and plastic and hard rubber from battery cases.

Samples of these materials exhibit elevated lead concentrations as well as other heavy metals associated with the secondary lead smelting industry.

Adjacent property owned by TCT was sampled during the IEPA 1983 study. The results indicated elevated lead concentrations. SLLR property has also been tested with a similar determination.

### 1.03 Remedial Investigation Summary

The objectives of the RI were to:

- 1) identify environmental conditions on and off the site relative to facility operations;
- 2) address potential health and environmental impacts resulting from the existing environmental conditions; and
- 3) develop a set of preliminary remedial technologies to be evaluated during the Feasibility Study.

To accomplish these objectives samples of on-site and off-site surface soils, waste materials from the slag piles and SLLR pile, surface water, and ground water were obtained and analyzed for heavy metals and other inorganic parameters. The analytical results were used to determine potential health and environmental impacts associated with the observed environmental conditions and to identify preliminary remedial technologies.

The field activities included sampling ground water and measuring ground water elevations during each of the seasons of 1987. Two additional wells were installed to clarify ground water flow directions. Eight soil borings in the vicinity of the slag pile were conducted to clarify the extent and nature of an underlying clay material. In

addition, two test pits were excavated in the slag pile to provide information on the stratigraphy within the pile.

The analytical program included analysis for many metals as well as selected anions and indicator parameters. A detailed evaluation of the data generated concluded that the data were useable for the purposes of the Remedial Investigation/Feasibility Study.

#### 1.04 Overview of Report

This Report has been divided into ten sections of text, followed by references, tables, figures, appendices, and exhibits. A brief overview of the Report follows.

Section 1 presents information on the background of the Site and the nature and extent of the problem associated with the Site. In addition, the section provides a description of the objectives of the RI and the structure of the Report.

Section 2 presents information on the Site's features. Features addressed include demography, land use, natural resources, and climatology. This information provides an environmental setting for this study area.

Section 3 presents the procedures and results of the hydrogeologic investigation. It includes a description of regional geology and hydrology. In addition, the section presents the site-specific information generated by the subsurface investigation. Included is an interpretation of ground water flow direction and velocity as well as water quality analyses.

Section 4 presents the results of the waste pile investigation. It includes a description of the physical characterization of the slag pile and the analytical results of samples from the waste piles.

Section 5 presents the results of the soils investigation, including a summary of analytical data and an evaluation of the data relative to site activities. The investigation included sampling of on-site and off-site surface soils.

Section 6 presents the findings of the surface water investigation. This includes a discussion of analytical data from samples of surface runoff and deposition from the waste pile.

Section 7 presents the results of the air investigation, which consisted of an evaluation of air quality data collected by IEPA air monitoring stations used for the SIP.

Section 8 presents a discussion of public health and environmental impacts. The section identifies potential receptors that may be affected by the observed environmental conditions, and summarizes public health and environmental concerns associated with the observed environmental conditions.

Section 9 presents remedial response objectives developed from data generated by the RI and chemical based potential ARAR's.

Section 10 presents the preliminary remedial technologies to be evaluated during the Feasibility Study. The preliminary remedial technologies were developed pursuant to the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), and the Superfund Amendments and Reauthorization Act of 1986 (SARA).

The reference section presents bibliographic citations for the sources used and cited in the text of the Report.

Tables have been prepared to summarize the data generated as part of the RI.

Figures have been prepared to help summarize and present key issues.

The Appendices section includes raw data, calculations, and other materials prepared by O'Brien & Gere which support the interpretations presented in the Report.

Exhibits include tables, reports, or other information prepared by an organization other than O'Brien & Gere which would assist a reviewer in understanding the Report.

## SECTION 2 - SITE FEATURES INVESTIGATION

### 2.01 Demography

Granite City, Illinois is located in the greater St. Louis metropolitan area, which has a population of approximately 2.5 million people. Granite City has a population of approximately 40,000 people.

### 2.02 Land Use

Land use in the area around the Site includes heavy industrial, commercial, and residential uses. The land use map for the area is presented as Figure 6. Among the industries in the vicinity of the site are:

- Granite City Industrial Corporation
- Granite City Steel Division
- Nesco Steel Barrel Company
- National Steel Corporation
- Illinois Power Company
- Reilly Tar and Chemical Corporation
- Corn Products Refining Company
- Jennison - Wright Corporation
- Illinois Terminal Company
- Cain Steel Company
- Illinois Power and Light Corporation
- United States Army
- Granite Intake Corporation
- Amsted Industries, Incorporated
- Midwestern Drum Service, Incorporated

- Shasta-Illinois, Incorporated
- Laclede Steel Company
- Fox Industries, Incorporated
- Conalco
- Terminal Railroad Associates
- Chicago and Northwestern Railroad
- Illinois Central Gulf Railroad

The locations of these industries are depicted in Figure 7.

### 2.03 Natural Resources

The Site lies in the Mississippi River Valley. The Mississippi River is located approximately 2 miles to the west of the Site and the Chain of Rocks Canal is 1-1/2 miles to the west-northwest of the Site.

Underlying the Site is the American Bottoms aquifer. The American Bottoms is a very productive sand and gravel aquifer, which is discussed in greater detail in Section 3.

The soils in the area belong to the Riley-Landes-Parkville Association, which consists of nearly level to gently sloping silty clay loam, silty clay, and fine sandy loam, formed in loamy and sandy alluvium sediments under grass and/or forest cover. Most of the soils are poorly to very poorly drained, although some are moderately well to well drained.

The Site is not located in the 100 year flood plain (Granite City, 1987).

#### 2.04 Climatology

The St. Louis metropolitan area has normal maximum and minimum January temperatures of 38 degrees F and 20 degrees F, and normal maximum and minimum July temperatures of 89 degrees F and 69 degrees F, respectively. The normal meteorological data are based on records for the thirty-year period from 1951 to 1980.

On the average, the St. Louis area receives approximately 35 inches of precipitation annually. The 1981 average pH of wet deposition was approximately 4.4 standard units (Interagency Task Force on Acid Precipitation, 1982). Typically, a pH range of 5.0 to 5.6 is considered normal for wet deposition in the absence of man-made emissions. Therefore, the area is impacted by acid precipitation.

## SECTION 3 - HYDROGEOLOGIC INVESTIGATION

### 3.01 Background Hydrogeology

The Granite City Site is located in the southwestern portion of Madison County, Illinois within the Mississippi River valley. The site is approximately eight to ten miles south of the confluence of the Mississippi and Missouri Rivers. The site is underlain by recent alluvium and glaciofluvial and glaciolacustrine deposits. Bedrock beneath the alluvium is Carboniferous age rocks consisting of limestone, sandstone and shale. The alluvial and glacial deposits which fill the valley range in thickness from less than one foot adjacent to the bluff boundary and the Chain of Rocks reach of the Mississippi River to greater than 170 feet near the City of Wood River. The fill thickness across the entire area averages approximately 120 feet (Collins and Richards, 1986). The estimated thickness of the valley deposits beneath the site is approximately 100 to 120 feet. Investigations conducted by the Illinois State Water Survey (Piskin and Bergstrom, 1975) have revealed the valley deposits become progressively coarser with depth. Generally, ground water in the Granite City area occurs within the unconsolidated valley deposits under unconfined and leaky confined conditions. Recharge of ground water within the area is from precipitation and induced infiltration of surface water from the Mississippi River and smaller surface water bodies in the area.

A search of available hydrogeologic data (references) indicates that at least 36 wells are located within a two mile radius of the site (Figure 5). Table 1 provides a list of the wells including the reputed owner,

use, and well depth. Whether these wells are still used was not determined as part of the RI.

### 3.02 Hydrogeologic Field Investigation

#### 3.02.1 Introduction

In January, 1987, O'Brien & Gere conducted a hydrogeologic investigation at the Granite City site which involved natural gamma borehole logging, in-situ hydraulic conductivity testing and ground water sampling of twelve existing ground water monitor wells (Figure 8).

The existing monitor wells were installed proximate to and on the site as a two phase ground water investigation which began in October, 1982. At that time the Illinois Environmental Protection Agency (IEPA) installed four monitor wells, G-101, G-102, G-103, and G-104 around the perimeter of the site as illustrated in Figure 8. Following laboratory analyses which demonstrated elevated concentrations of lead in soil samples from soil boring #1 (completed as Well G-101) and ground water samples from Well G-104, eight additional monitor wells (G-105S, G-105D, G-106S, G-106D, G-107S, G-107D, G-108S and G-108D) were installed on the site in July, 1983. The eight wells were installed in pairs as a well nest, one shallow and one deep well at each of four locations.

In July, 1987, ground water monitor wells, MW-109 and MW-110, were installed by NL Industries, in accordance with the Addendum to the Work Plan dated July 1987, proximate to the site to assess the ground water flow direction in the deeper zone. Figure 8 illustrates the location of the monitor wells. Laboratory

analyses completed on soil samples collected during well installation are summarized on Table 15.

### 3.02.2 Natural Gamma Borehole Logging

Ground water monitor wells G-101, G-102, G-104, G-105D, G-106D, G-107D and G-108D ("D" denotes deep well) were logged at two foot intervals using a Johnson/Keck GR-81 natural gamma logger in accordance with the protocols presented in the RI/FS Work Plan (O'Brien & Gere, 1986). Gamma logging was utilized for the purpose of enhancing the lithologic information presented on the IEPA test boring logs providing basic information on three wells lacking boring logs and as a means of delineating low permeability zones which may not have been observed during drilling and sampling. Boring logs provide a more accurate description of the subsurface materials where samples were collected. However, most of the older wells, G-101, G-102, G-103, and G-104 were only sampled at five foot intervals. The deeper portions of the newer wells G-105D, G-106D, G-107D, and G-108D were sampled at five foot intervals or logged from drill cuttings. Generally, the gamma log data confirmed that the sediments beneath the site generally consist of sand, silt, and clay overlying predominantly sand. Gamma log data obtained from monitor wells G-101, 102, and 104 suggest that silt and clay sized sediment may be a significant component of the subsurface materials in the vicinity of the screened portion of these wells. Gamma counts indicative of silt and clay were recorded from these wells within an interval of 12 to 22 feet below the surface. These data suggest that the shallow

sediments at the southern end of the site may be of a finer grain texture than those encountered throughout the remainder of the site. Gamma logs of the deeper wells, 105D through 108D, are generally consistent with the boring logs. The well 108 gamma log suggests fine grained sediments are present at a depth of 22 feet which were not logged during the drilling of the well. These results are attributed to discrete lenses of finer grained sediments within the coarser sediments. Appendix B provides the results of the gamma log data.

### 3.02.3 Hydraulic Conductivity Tests

In-situ hydraulic conductivity tests were performed using an Enviro-Labs EL-120 MCP Data Logger with pressure transducers in monitor wells G-101, 102, 104, 105, 105D, 107, 107D, 108 and 108D. Both rising head (positive displacement) and falling head (negative displacement) tests were performed in accordance with the approved Work Plan by creating an artificial head in the well through the insertion and/or removal of a teflon rod.

Conductivity tests performed on wells MW-109 and 110 did not involve the use of the Enviro-Labs Data Logger. These tests were conducted by producing a rising head through pumping of the well and measuring the water level recovery with a well probe. Hydraulic conductivity tests performed on wells 109 and 110 were unsuccessful due to the recovery rate of the water table being too rapid for measurement. The rapid recovery suggests that the hydraulic conductivity of the aquifer at these locations is greater than about  $1 \times 10^{-3}$  cm/sec.

The in-situ hydraulic conductivity test data were analyzed using Hvorslev's Method to determine the horizontal hydraulic conductivity of the screened portion of the aquifer in each well. Appendix C provides the results of the hydraulic conductivity tests. The horizontal hydraulic conductivity of the site ranged from 11.2 gpd/ft<sup>2</sup> ( $5.3 \times 10^{-4}$  cm/sec) to 361.0 gpd/ft<sup>2</sup> ( $2.0 \times 10^{-2}$  cm/sec) within the shallow portion of the aquifer and 9.1 gpd/ft<sup>2</sup> ( $4.3 \times 10^{-4}$ ) to 1293.0 gpd/ft<sup>2</sup> ( $6.1 \times 10^{-2}$  cm/sec) in the deeper zone. The hydraulic conductivity at wells 109 and 110 were assumed to be within the range of the other deeper wells given the similar lithologies.

#### 3.02.4 Monitor Well Installation

In July 1987, ground water monitor wells MW-109 and 110 were installed to the same depth as the previously installed deep wells (105D, 106D, 107D and 108D) to evaluate the direction of ground water flow within that portion of the aquifer. Monitor well MW-109 was installed south of the site to a depth of thirty five feet below the surface. Monitor well MW-110 was installed to the same depth, northeast and hydraulically upgradient of the site. Each well was installed in accordance with the RI/FS Work Plan Addenda (O'Brien & Gere, 1987) with 10 ft. of two inch diameter PVC well screen (0.010 inch slot). Exhibit B provides the test boring logs for monitor wells MW-109 and 110.

#### 3.02.5 Ground Water Sampling

In January, April, August and November 1987, the ground water monitoring wells were sampled in accordance with the protocols presented in Appendix D of the RI/FS Work Plan and the Addendum to the Work Plan dated July, 1987. Ground water wells G-105, G-106, and G-108 did not contain enough water to sample after the first round of sampling. In addition, to collecting ground water samples, water levels were measured on seven occasions.

#### 3.03 Site Hydrogeology

Data obtained from the test borings completed as ground water monitor wells installed by the IEPA have basically revealed an unconfined aquifer composed of sand and silt with some clay extending to at least 35 feet below the surface. Ground water has been encountered at an average depth of 24 feet below the surface. Test borings indicate the shallow portion of the aquifer contain a greater percentage of clay and silt than the deeper portions of the aquifer.

The aquifer materials become increasingly coarse with depth. This occurrence of coarser materials below finer materials is supported by the gamma logging performed on the site wells. Figure 9 illustrates in geologic cross section relative to monitor wells, the water table, and subsurface sediments. In spite of the generally finer grained texture in the shallow portion of the aquifer, the horizontal hydraulic conductivity results show similar values for both shallow and deep wells. This suggests that the site materials may be layered with some coarser layers occurring within the generally finer grained shallow

aquifer materials. The boring logs suggest some alternating layers of fine and coarse grained materials in the shallow aquifer.

Ground water elevation data for the site monitoring wells are presented on Table 2. The ground water elevation data obtained in September and October 1987 provided the most complete coverage and was therefore contoured to present the ground water flow direction across the site (Figures 10 and 11). The site data revealed a south-southwesterly ground water flow direction within the shallow portion of the aquifer with a hydraulic gradient range from 0.003 ft/ft to 0.00075 ft/ft. Ground water flow direction in the deeper portion of the aquifer was also south-southwesterly. The hydraulic gradient for the deeper portion of the aquifer from July 1987 to November 1987 ranged from 0.001 ft/ft to 0.0005 ft/ft. The south to southwesterly ground water flow direction is towards the Mississippi River.

The contours illustrated on Figure 10 do not reflect ground water elevations observed in monitor wells 107D and 107S. These elevated ground water elevations may be attributed to added recharge as it was unpaved in this area at the time of the field activities, and/or slower vertical attenuation of the ground water as it percolates down through zones of finer grained sediment. The hydraulic conductivity tests demonstrated that the conductivity of wells 107D and 107S are at least one order of magnitude less than the conductivity of the surrounding wells.

The site-wide ground water monitor well elevation data are presented on Table 2. Well nest G-107S and D has shown a consistent downward vertical gradient averaging 0.21 ft/ft. Well nest G-108S and D has shown a consistent downward gradient averaging 0.030 ft/ft,

when ground water was present in the shallow well. Well nest G-106S and D has limited data but has shown an upward vertical gradient averaging 0.0053 ft/ft. Well nest G-105S and D also has limited data and indicates a variable gradient. The shallow well has been dry on each of six test periods since January 1987. This may be related to the paving of the Taracorp property during 1986 which would reduce local recharge. Variables which could impact the gradient include recharge, subsurface stratigraphy, and ground water withdrawal.

A range of hydraulic gradients derived from the ground water elevation data and hydraulic conductivities obtained from the in-situ hydraulic conductivity tests were used to calculate a range of ground water flow velocities for each zone. The following provides the data and calculated ground water velocities:

Hydraulic Gradient:

- a) Shallow zone range - 0.003 to 0.00075 ft./ft.
- b) Deep zone range - 0.001 to 0.0005 ft./ft.

Hydraulic Conductivity:

- a) Shallow zone range -  $2.0 \times 10^{-2}$  to  $5.3 \times 10^{-4}$  cm/sec.  
56.7 to 1.5 ft/day
- b) Deep zone range -  $6.1 \times 10^{-2}$  to  $4.3 \times 10^{-4}$  cm/sec.  
172.9 to 1.2 ft/day

Linear Ground Water Flow Velocity:

$$V = (K)(i)/(n)$$

Where: V = Ground Water Flow Velocity (ft./day)

K = Hydraulic Conductivity (ft/day)

i = Hydraulic Gradient (ft./ft.)

n = Estimated Porosity (unitless)

Shallow Zone:

$$\text{High Range: } (56.7)(0.003)/(0.35) = \underline{4.9 \times 10^{-1} \text{ ft./day}}$$

$$\text{Low Range: } (1.5)(0.00075)/(0.35) = \underline{3.2 \times 10^{-3} \text{ ft./day}}$$

Deep Zone:

$$\text{High Range: } (172.9)(0.001)/(0.35) = \underline{4.9 \times 10^{-1} \text{ ft./day}}$$

$$\text{Low Range: } (1.2)(0.0005)/(0.35) = \underline{1.7 \times 10^{-3} \text{ ft./day}}$$

The linear ground water flow velocity has been calculated as ranging from  $3 \times 10^{-3}$  ft/day to 0.5 ft/day in the shallow portion of the aquifer and  $2 \times 10^{-3}$  ft/day to 0.5 ft/day in the deeper zone.

### 3.04 Ground Water Chemistry

The first round of ground water samples from the 12 monitoring wells were obtained in January, 1987. The sampling procedures which were utilized are detailed in Appendix D of the RI/FS Work Plan. The samples were analyzed for sulfate, total dissolved solids, and the following filterable metals: antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, selenium, and zinc. In addition, samples from wells G-102, G-106D, and G-108S were analyzed for total lead concentration. Each well where water was present was sampled in April for a list of parameters defined in the RI/FS Work Plan. Samples obtained in August and November, 1987, were collected from monitor wells 101, 107D, 108D, 109 and 110. The analytical results for each round of samples are presented in Appendix D and summarized in Tables 12, 13 and 14.

The purpose of this subsection is to present an interpretation of the ground water quality data, not to present all of the data contained

in Appendix D and the summary tables. All of the ground water quality data are useable for evaluating ground water quality in the monitoring wells as described in Appendix E.

Examination of the data presented in Table 12 and Table 13 indicates that ground water quality over the period of the study was reasonably consistent. Wells 101, 107D, and 108D were sampled on four occasions over a twelve month period. Calculation of the standard deviation for sulfate at each well and comparing that value to the mean provides an indication of the range of values observed. The standard deviation for these wells was calculated to be in the range of 7% to 10% of the mean, indicating consistent ground water quality at a particular location over the 12 month study period.

Establishing background water quality in the vicinity of the site is complicated by several factors. Section 3.03 presented data indicating that the hydraulic gradient across the site is less than 0.003 ft/ft. Process water supply wells on adjacent properties which tap the unconsolidated sediments could influence this gradient. The area surrounding the site is heavily industrialized. Finally the unconsolidated deposits are quite variable in nature, ranging from clays to coarse sands.

Four wells were selected based on ground water elevations during 1987 and water quality as representing "background" water quality in the vicinity of the site. These wells, 102, 105S, 105D, and 110 are located north and east of the site. The concentration ranges observed for these wells were as follows:

Total Dissolved Solids: 610-1000 mg/l

Conductivity: 680-1100 micromhos/cm

Sulfate: 120-320 mg/l

pH: 6.3-6.8 S.U.

Filterable Iron: LT 0.1-0.12 mg/l

Filterable Manganese: LT 0.025-0.99 mg/l.

Filterable Lead: LT 0.005-0.013 m/l

Filterable Nickel: LT 0.01-0.02 mg/l

Filterable Cadmium: LT 0.001-0.006 mg/l

Filterable Zinc: 0.013-0.03 mg/l

Three wells 101, 108S, and 108D have consistently demonstrated elevated concentrations of several parameters. Although monitoring well 101 is slightly hydraulically upgradient, it is quite close to the slag pile and may be influenced by localized mounding. Ground water from this well demonstrated average concentrations of iron (21 mg/l), manganese (4.7 mg/l), arsenic (0.079 mg/l) and zinc (0.039 mg/l), higher than observed at the background shallow well, 105S. Other parameters were similar to well 105. Well 108S could only be sampled on one occasion due to low ground water elevation. The results demonstrate elevated concentrations relative to background of sulfates (1250 mg/l), dissolved solids (3110 mg/l), cadmium (0.209 mg/l), and manganese (13.1 mg/l). In addition to these parameters being elevated, (average: sulfates - 1760 mg/l, dissolved solids - 4320 mg/l, cadmium - 3.9 mg/l, and manganese - 25 mg/l), well 108D also contained nickel (0.74 mg/l) and zinc (42 mg/l) relative to well 110, the background deep well. The high total dissolved solids and sulfates at the 108 wells may be explained by the proximity to the former battery breaking operations. Each of these wells contained less than 0.01 mg/l of lead.

Seven wells located to the south and west of the Taracorp manufacturing area and slag pile have been selected to evaluate water

quality hydraulically down gradient of the site. These wells, 103, 104, 106S, 106D, 107S, 107D, and 109 screen the water table aquifer in the range of 382-406 feet USGS, with a water table at approximately 400 feet USGS.

The two wells located south of the site, 103 and 109, produced water quality suggesting no contaminant migration from the site in this direction. Total dissolved solids (520 mg/l), conductivity (720 micromhos/cm), sulfates (130 mg/l), pH (6.6 S.U.) and the presence of only five of the 14 metals analyzed at or near the detection limits characterized the water quality south of the site.

Each of the wells west of the site had water quality within or close to the ranges observed for background with the exception of 104, 106S and 107D. Well 104, despite being the well with the lowest ground water elevation of those studied, had water quality as defined by dissolved solids (380 mg/l) and sulfates (125 mg/l) better than that observed in the "background" wells. However, 104 did have a depressed pH which averaged 5.6 S.U. Well 106S which could only be sampled on one occasion due to low ground water, yielded water with a cadmium concentration of 0.013 mg/l, however, the remainder of the parameters fell within the background well ranges. Well 107D was sampled on four occasions, consistently yielding water with elevated sulfates (507 mg/l), total dissolved solids (1290 mg/l), and iron (6.7 mg/l). Manganese and other metals were within the ranges observed at the background wells. The down gradient wells consistently yielded water that was generally similar in quality to background deep Well 110 and background shallow Well 105S, except as noted above. Metal concentrations, were generally less than detectable.

Ground water quality data indicate a ground water flow in a southwesterly direction, consistent with ground water elevations reported in Section 3.03. Recharge from the pile and the remainder of the site is limited by the extensive on-site paving as well as a low permeability clayey sand layer beneath a minimum of 72% of the surface area of the slag pile. A more reasonable estimate would be 86% based on the soil boring information presented in Figures 12 and 18, and Exhibit F. However, the data available from well 108D do suggest that dissolved solids and metals from the pile have entered the water table aquifer to an elevation of 385-390 feet USGS. This elevation is beneath the screened interval of well 104 so deeper migration to the west is possible and should be evaluated further.

All the wells around the perimeter of the site demonstrate heavy metal concentrations within or close to the ranges observed for the background wells. The observed low concentrations of metals in the ground water beneath such a substantial source as the slag pile requires comment. One factor which limits transport of metals from the slag pile to ground water is the low permeability clayey sand discussed in Section 4.02, which is beneath a minimum of 72% of the slag pile. The fact that over 99% of the site is paved or beneath the slag pile also limits runoff recharge to ground water. This percentage is based on the fact that the entire site is 15.25 acres in size. The entire site is paved with the exception of the area underlying the slag pile (3.0 acres), and a 0.26 acre area in the area of Well 105 and the railroad siding near the Mixed Metals A and B buildings. The second factor is the high alkalinity and sulfates within the ground water hydraulically upgradient of the site. Mundell, et al. 1987 presented a paper which

demonstrated that in ground water systems, lead migration is limited by the solubility of lead carbonate, and lead sulfate. The solubility products for these substances are sufficiently low as to have this mechanism included as a promising technology for remediation of hazardous waste sites (USEPA, 1985).

added  
6/8  
Data generated by the Illinois EPA during 1983 and presented as Table 14 suggests that some lead may have migrated from the surface to the ground water table. Acid precipitation may enhance the solubilization of heavy metals in percolating precipitation, although other factors such as the cation exchange capacity of the soil would be expected to also affect the solubility of metals. Percolation when contacted by the ground water with high alkalinity could have deposited the metal at the interface. This was most noticeable at location 101, however, it was also observed at 107 and 108. These mechanisms apparently limit the migration of the heavy metals within the ground water system.

## SECTION 4 - WASTE PILE INVESTIGATION

### 4.01 General

A series of waste piles are present on the site in the slag storage area shown on Figure 3. The waste piles were surveyed in 1987 by Sheppard, Morgan & Schwaab, Inc. The topographic plat generated by the survey is presented as Figure 12.

The largest pile, herein referred to as the slag pile, consists of wastes from the smelting process, including slag, matte, hard rubber and plastic from battery cases, lead and iron oxide. The total volume of the slag pile is approximately 85,000 cubic yards. The composition of the pile was estimated on a tonnage basis to be approximately 250,000 tons of which 50% was blast furnace slag, 20% battery case material, 20% lead oxide dust, 3% antimonial lead, and the remainder miscellaneous debris (OH Materials, 1987). The field investigation included excavation of two test pits to provide information on slag pile composition. In addition, approximately 25-35 drums of unrecycled drosses and bag house dust were observed during the field investigations (S.W. Holt, 1987).

The other smaller waste piles are located south-southwest of the slag pile and are a result of SLLR's recycling of the slag pile. The largest of these piles is known as the SLLR pile, and consists of hard rubber battery case chips and lead and iron oxide. The SLLR pile is on property owned by Trust 454 and leased by SLLR. The other small waste piles appear to be comprised largely of slag and matte. The SLLR pile contains approximately 3,900 cubic yards of material. The

three smaller piles are approximately 1,400, 70 and 1,000 cubic yards in volume.

Several samples of the slag pile and SLLR pile were obtained and analyzed during the RI. All the data were determined to be usable relative to the overall objectives of the project as described in Appendix E. In addition, a physical characterization of the slag pile was conducted to estimate types and quantities of materials present in the pile. The following sections present the findings of the waste pile investigation.

#### 4.02 Physical Characterization

The physical characterization of the slag pile consisted of excavating two areas of the slag pile with a backhoe. Observations regarding the types and approximate thickness of the layers of materials were recorded.

Figure 12 illustrates the locations of the two excavations. The descriptions of the strata identified in the two excavations are presented in Tables 3 and 4.

Excavation 1 appeared to be visibly more stratified than Excavation 2 with no battery case material observed more than seven feet below grade. This observation suggests that the material in the vicinity of Excavation 1 is primarily slag with some battery case material placed on top. This is consistent with visual inspection of the north end of the pile adjacent to the parking area.

Excavation 2, contained more battery case material. Given the heterogeneous nature of the pile for purposes of the RI it is assumed that each pit represented 50% of the slag pile.

The test pit excavation results can be used to provide an approximation of the volumes of materials present in the pile. This information coupled with density information can be used to estimate relative weights of materials present. Visual observations suggest that blast slag represents 55% of the pile on a volume basis, while case material accounts for 40% by volume. The remainder is assumed to be lead oxide and sulfate which was not recovered from the batteries when they were broken.

Assuming that slag has a specific gravity of approximately 5, lead compounds averaging 8, and the battery case material averaging approximately 1, the mass of the pile is calculated to be 260,000 tons. This matches well with the estimate of 250,000 tons made by OH Materials (1987).

The large differences in specific gravities result in substantial differences between percentage by volume and percentage by weight. Based on the volumes percentages and specific gravities it is estimated that 200,000 tons of the pile is waste blast slag, 30,000 tons case material and 30,000 tons lead oxide/sulfate. These percentages are not surprising considering blast slag was generated since the early 1900's while battery breaking began during the 1950's.

Clay-like soils were found to be present in both excavations immediately below the waste materials. Three disturbed samples of the clay were obtained and analyzed for Atterberg Liquid and Plastic Limits (ASTM D4318) and Mechanical and Hydrometric Grain Size (ASTM D422). The results, presented as Exhibit A, indicate that the samples were comprised of fine-grained materials, typical of low permeability soils. One of the samples is classified using the Unified Soil Classification

System (ASTM D2487) as a clay while the other two are classified as clayey-sands. The permeability of the clay and clayey sand is estimated to be in the range of  $1 \times 10^{-6}$  to  $1 \times 10^{-7}$  cm/sec. The 20% or greater clay content of the matrix will control the permeability. These approximations are based on the reference information provided in Exhibit A.

The presence of low permeability soils beneath the waste materials of the slag pile was confirmed by the excavation activities. However, the horizontal extent and thickness was not determined during the excavation. A review of available information presented in Exhibit F, including logs for soil borings conducted in the early 1900's, indicates that this low permeability layer is naturally occurring and is generally consistent beneath the pile (Weddendorf, 1985). Nine of ten borings described the clay as being present.

A series of test borings around the perimeter of the slag pile were completed to determine the horizontal extent of the low permeability materials beneath the pile. Eight test borings were completed at the locations presented on Figure 12. The presence of the clayey sand layer beneath the slag pile is indicated in the cross-sectional views presented on Figure 17. The test boring logs are presented in Appendix F. Undisturbed samples of the low permeability materials encountered at test borings 1, 2, 3, 4, 7 and 8 were collected in Shelby tubes using ASTM Method 1586-D. Samples from test borings 5 and 6 were not collected. Test boring 5 had an approximately two foot clay and silt layer that was penetrated by the Shelby tube. However, it was inadvertently discarded and not retained for analysis. The materials encountered in test boring 6 did not appear to be of low permeability.

The remaining six Shelby tube samples were analyzed for laboratory permeability using a Triaxial apparatus with back pressure saturation as indicated in the methods of the Army Corps of Engineers, Laboratory Soils Testing, Manual EM 110-2-1906, Appendix VII. The results of the laboratory permeability testing are presented in Exhibit C. The coefficient of permeability as measured in the laboratory ranged from  $6.69 \times 10^{-7}$  cm/sec to  $1.97 \times 10^{-8}$  cm/sec.

#### 4.03 Chemical Characterization

Four types of samples from the waste piles were collected and analyzed during the RI. Blast furnace slag samples, materials from the upper strata of the slag pile, samples of drummed material, and samples of material from the SLLR pile were obtained.

A total of four composite slag samples were collected from the slag pile. As shown in Figure 12, the slag pile was divided into four approximately equal areas. Within each quadrant, four samples were obtained using geologic tools from four pieces of slag. The 16 subsamples were then composited to make one composite slag sample for each quadrant. Specific sampling procedures are detailed in the Sampling Plan (Appendix D of the RI/FS Work Plan).

The analytical results for the slag samples are presented in Appendix G. The results indicate that the slag contains antimony (410 mg/kg - 1,600 mg/kg), arsenic (620 mg/kg - 2,200 mg/kg), barium (212 mg/kg - 1,097 mg/kg), cadmium (19 mg/kg - 126 mg/kg) chromium (7.5 mg/kg - 23.2 mg/kg), copper (5,800 mg/kg - 11,000 mg/kg), iron (21,000 mg/kg - 340,000 mg/kg), lead (15,000 mg/kg - 37,300 mg/kg), and silver (less than 5 mg/kg - 6.7 mg/kg). The results of the EP

Toxicity procedure indicate the slag is a characteristic hazardous waste, due to the EP Toxicity lead concentrations of 147 mg/l and 312 mg/l.

Ten samples from the portion of the slag pile known as the upper strata were obtained. The upper strata refers to the surface materials on top of the slag pile. The upper strata sampling locations are presented in Figure 12. The samples were collected using a shovel which was decontaminated between samples. The samples were sieved in the field such that only that material passing through a 9.5 mm standard sieve was collected. Specific sampling procedures are detailed in the Sampling Plan (Appendix D of the RI/FS Work Plan).

Table 5 presents the analytical program for the upper strata samples. All ten samples were analyzed for the total metals indicated in the table. In addition, five of the samples were also analyzed for EP Toxic metals.

The analytical results for the upper strata samples are presented in Appendix G. The upper strata samples exhibited relatively wide ranges of the metals analyzed; antimony (630 mg/kg - 6,400 mg/kg), arsenic (130 mg/kg - 12,000 mg/kg), barium (115 mg/kg - 458 mg/kg), cadmium (6 mg/kg - 640 mg/kg), chromium (less than 5 mg/kg - 36 mg/kg), copper (2.9 mg/kg - 17,000 mg/kg), iron (413 mg/kg - 336,000 mg/kg), lead (45,000 mg/kg - 279,000 mg/kg), manganese (20 mg/kg - 2,290 mg/kg), mercury (less than 0.5 mg/kg - 1.6 mg/kg), nickel (6.5 mg/kg - 423 mg/kg), silver (less than 5 mg/kg - 24.2 mg/kg), and zinc (15.3 mg/kg - 13,840 mg/kg) were observed. Four of the five upper strata samples analyzed for EP Toxic metals exhibited EP Toxic lead concentrations sufficient to characterize them as hazardous. One of the samples was also EP Toxic for cadmium.

The sieving procedure (i.e. through a 9.5 mm standard sieve) was derived from 40 CFR 261 for testing hazardous waste characteristics. The materials passing through a 9.5 mm sieve would include particles of a size small enough to be transported by wind or runoff under extreme meteorologic conditions.

Two samples of the drummed material on the slag pile were collected using the procedures outlined in the Sampling Plan (Appendix D of the RI/FS Work Plan). The analytical program for the drummed material samples is presented in Table 5. The two samples were analyzed for the list of metals in the table. One of the samples was also analyzed for EP Toxic metals.

The analytical results for the drummed material samples are presented in Appendix G. The results indicate that the materials were somewhat different in composition. Elevated concentrations of cadmium (2,700 mg/kg) and lead (237,000 mg/kg) were observed in one of the samples, whereas lead (273,000 mg/kg) was detected in the other sample. EP Toxicity results demonstrate that the drummed waste was EP Toxic for cadmium and lead.

Three samples of material were collected from the SLLR pile. The sampling locations are presented in Figure 12. The samples were collected using a shovel which was decontaminated between samples. The SLLR pile samples were sieved in the field such that only those materials passing through a 9.5 mm standard sieve were collected. Detailed sampling procedures are documented in the Sampling Plan (Appendix D of the RI/FS Work Plan).

Table 5 presents the analytical program for the SLLR pile samples. The samples were analyzed for the total metals indicated in the table. One of the samples was also analyzed for EP Toxic metals.

The analytical results for the SLLR pile samples are presented in Appendix G. The data indicate relatively wide variations in metals concentrations between the samples. For example, arsenic concentrations ranged from 5.6 mg/kg to 4,100 mg/kg, cadmium ranged from 15 mg/kg to 7,000 mg/kg, iron ranged from 8,240 mg/kg to 33,700 mg/kg, and lead ranged from 105,000 mg/kg to 286,000 mg/kg. Similarly, antimony ranged from 200 mg/kg to 2,900 mg/kg, and zinc ranged from 383 mg/kg to 42,100 mg/kg. The EP Toxicity results demonstrated that the SLLR pile sample was EP Toxic for lead.

#### 4.04 Summary

The slag pile and assorted piles at the SLLR facility include approximately 91,000 cubic yards of wastes from secondary lead smelting operations of which approximately 80% (w/w) is blast furnace slag. The slag pile is a heterogenous mixture of materials ranging in size from lead oxide dust to blast furnace slag with particle weights in excess of 1,000 pounds. Combined with these materials are broken battery case material of hard rubber and plastic.

Despite material variability, all the materials sampled had concentrations of lead in excess of 1% and in some cases as high as 28% (w/w). Testing indicates that the lead and cadmium are available for leaching and thus would be a characteristic hazardous waste.

## SECTION 5 - SOILS INVESTIGATION

### 5.01 General

The soils investigation for the Granite City RI/FS included the collection and analysis of 98 surface soils from 52 locations on and off the site. A rectangular grid was superimposed over the site and surrounding properties encompassing an area of approximately 575 acres within 0.5 mile radius of the site. A total of 41 grid locations were sampled as presented in Figure 13. The balance of the samples were obtained from more remote areas, where battery case chips were allegedly taken and used as paving and fill materials. The sampling locations in the remote removal areas are presented in Figures 14 and 15.

The soil samples from each grid location were obtained as composites at depths of 0 to 3 inches and 3 to 6 inches from grade. Samples from five of the locations in the off-site removal areas were also composite samples obtained at depths of 0 to 3 inches and 3 to 6 inches from grade. The compositing procedure utilized is presented in detail in the RI/FS Work Plan. Briefly, it consisted of hand-driving 3/4-inch Lexan<sup>R</sup> tubing to the specified depth at the northernmost, southernmost, easternmost, and westernmost points on a 3-meter diameter circle. The four subsamples were composited. Vegetative material in the samples was dissected out such that the composite samples consisted only of mineral soil.

Soil samples from six of the locations in the remote fill areas were surface grab samples rather than composites due to field conditions at the time of sample procurement. At these locations, a clean shovel was

used to obtain the samples. Each of these sample locations was in an alley.

The soil samples were initially analyzed for lead and total solids. Upon review of the initial data, the surface soil samples were analyzed for lead, cadmium, arsenic, chromium, zinc, antimony, and total solids at the direction of the USEPA. One off-site soil sample was analyzed for EP Toxic metals. Analytical procedures for the initial soil analysis and quality assurance/quality control requirements for all samples are presented in the RI/FS Work Plan. The analytical procedures utilized for the additional analysis included EPA Method 200.7 for lead, cadmium, chromium, zinc, and antimony; and EPA Method 206.2 for arsenic. All the data were determined to be usable relative to the overall objectives of the project as presented in Appendix E.

## 5.02 Soil Sampling Grid

### 5.02.01 Initial Analytical Results

The analytical results for the soil grid samples are presented in Figure 13 and Appendix H. The soil lead concentrations ranged from 136 mg/kg (dry weight) to 9,250 mg/kg for the samples taken from 0 to 3 inches in depth, and 45 mg/kg to 48,400 mg/kg for the 3 to 6 inch depth samples. Excluding the soil samples collected on-site (sample location 15), the ranges in soil lead concentrations were 136 mg/kg to 9,250 mg/kg and 45 mg/kg to 14,700 mg/kg for the 0 to 3 inch and 3 to 6 inch depths, respectively.

Excluding the anomalous value from location 18, the range of concentrations for the off-site grid samples at the 3 to 6 inch depth was 45 mg/kg to 1810 mg/kg. The mean soil lead

concentrations for the off-site grid samples were 1160 mg/kg and 560 mg/kg for the 0 to 3 and 3 to 6 inch depths, respectively. The median soil lead concentrations for the 0 to 3 and 3 to 6 inch depths were 725 mg/kg and 498 mg/kg, respectively.

The soil sample representing the 0 to 3 inch depth from location 110 was analyzed for EP Toxic metals. The analytical results are presented in Appendix H. This sample was chosen for EP Toxicity testing due to its total lead concentration of 3110 mg/kg (dry weight), which was considered to be representative of the higher soil lead concentrations of those residential off-site samples obtained from the soil sampling grid. The analytical results demonstrate that the soils do not exhibit hazardous characteristics with respect to the EP Toxicity procedure.

#### 5.02.02 Supplemental Analytical Results

The soil grid samples collected from the 0 to 3 inch depth were analyzed for lead, cadmium, chromium, arsenic, zinc, antimony, and total solids. The results of these additional analyses are presented in Appendix H. The metal concentrations for off-site grid samples ranged from 112 mg/kg to 5,320 mg/kg for lead, less than the detection limit of 2 mg/kg to 12 mg/kg for cadmium, 2.7 mg/kg to 62.4 mg/kg for arsenic, 15 mg/kg to 143 mg/kg for chromium, 121 mg/kg to 2,570 mg/kg for zinc, and 2 mg/kg to 61 mg/kg for antimony. The median concentrations observed in the off-site samples were 640 mg/kg lead, 3 mg/kg cadmium, 10.1 mg/kg arsenic, 30 mg/kg chromium, 400 mg/kg zinc, and 6 mg/kg antimony. The following metals concentrations

were observed in the grid sample collected from on-site: 15,300 mg/kg lead, less than the detection limit of 2 mg/kg cadmium, 73.3 mg/kg arsenic, 11 mg/kg chromium, 146 mg/kg zinc, and 54 mg/kg antimony.

### 5.03 Remote Fill Areas

#### 5.03.01 Initial Analytical Results

The two areas to which battery case chips were allegedly taken are Venice and Eagle Park Acres. A total of eight samples from seven locations in Venice were obtained, as shown in Figure 14. Eight samples from floor sample locations, shown in Figure 15, were obtained from Eagle Park Acres. The analytical results for the samples collected in Venice are presented in Figure 14 and Appendix H. Of the eight samples obtained from Venice, six (i.e., locations 37, 39-42, and 140) were samples of paving material collected from alleys using a clean shovel. The two samples from location 38 consisted of soil approximately one foot from the edge of a paved alley obtained using 3/4-inch Lexan<sup>R</sup> tubing. The two composite soil samples collected at location 38 were representative of depths from 0 to 3 inches and 3 to 6 inches below grade.

The lead concentration in the 0 to 3 inch sample at location 38 was 1440 mg/kg and that for the 3 to 6 inch depth was 5800 mg/kg. The lead concentrations from the alley samples ranged from 200 mg/kg to 126,000 mg/kg. The lead concentration of 126,000 mg/kg observed in the sample from location 40 is inconsistent with the other alley samples in this area. A sample obtained

in the same block (sample location 140) exhibited a lead concentration of 8200 mg/kg. Excluding the analytical result for the alley sample from location 40, the range in lead concentrations in the alley samples ranged from 200 mg/kg to 8200 mg/kg, with a mean lead concentration of 4140 mg/kg, and a median of 2670 mg/kg.

The analytical results for the samples collected in Eagle Park Acres are presented in Figure 15 and Appendix H. At each sample location in Eagle Park Acres, a composite sample was obtained for 0 to 3 inches and 3 to 6 inches below grade. These samples consisted of soil and fill materials from a large lot and ravine.

The lead concentrations in the 0 to 3 inch samples from Eagle Park Acres ranged from 63 mg/kg to 3280 mg/kg, with a mean lead concentration of 1450 mg/kg. The range in lead concentrations for the samples obtained from the 3 to 6 inch depth was 91 mg/kg to 4030 mg/kg. The mean lead concentration for the 3 to 6 inch depth samples was 1720 mg/kg.

#### 5.03.02 Supplemental Analytical Results

The surface soil samples collected from Venice and Eagle Park Acres were analyzed for lead, cadmium, chromium, arsenic, zinc, antimony, and total solids. The results of the additional analyses are presented in Appendix H.

As noted in Section 5.03.01, six of the samples collected from Venice were samples of paving materials from alleys. These samples were collected from locations 37, 39, 40, 140, 41, and 42.

The material sampled at location 38 was soil. The concentrations observed in the surface soil at location 38 were: 766 mg/kg for lead, less than 8 mg/kg for cadmium, 5.5 mg/kg for arsenic, 24 mg/kg for chromium, 247 mg/kg for zinc, and less than 8 mg/kg for antimony. The metal concentrations observed in the paving material samples ranged from 125 mg/kg to 95,500 mg/kg for lead, less than 2 mg/kg to 4 mg/kg for cadmium, 2.9 mg/kg to 41.2 mg/kg for arsenic, 9 mg/kg to 386 mg/kg for chromium, 294 mg/kg to 774 mg/kg for zinc, and 4 mg/kg to 495 mg/kg for antimony. The lead concentration of 95,500 mg/kg observed in the sample from location 40 is inconsistent with the others observed in the paving material samples. This was also the case in the initial analytical effort. Excluding the lead analysis for the sample from location 40, the lead concentrations in the paving materials ranged from 125 mg/kg to 7,010 mg/kg, with a mean concentration of 3,090 mg/kg, and a median concentration of 3,180 mg/kg.

The metal concentrations observed in the surface soil samples from Eagle Park Acres ranged from 19 mg/kg to 3,010 mg/kg lead, less than 2 mg/kg to 4 mg/kg cadmium, 3.3 mg/kg to 10.5 mg/kg arsenic, 12 mg/kg to 34 mg/kg chromium, 67 mg/kg to 880 mg/kg zinc, and 3 mg/kg to 11 mg/kg antimony. The mean concentrations were 1,150 mg/kg lead, 2 mg/kg cadmium, 7.8 mg/kg arsenic, 25 mg/kg chromium, 440 mg/kg zinc, and 7 mg/kg antimony.

#### 5.04 Summary

4150?

Soil lead sampling demonstrated surface soil (0-3") lead concentrations in residential neighborhoods within 2000 feet east of the site at averaging 1,770 mg/kg with a maximum value of 2,650 mg/kg. Surface soil lead concentrations determined for residential, commercial and industrial properties surrounding the site were less than 2,000 mg/kg for 80% of the samples not on Taracorp or St. Louis Lead Recyclers property with only one location on zoned heavy industrial property above 3,000 mg/kg. The observed lead soil concentrations in this study were similar to values reported in 1983 (IEPA, 1983). Remote sampling locations demonstrated a much wider range in lead concentrations, 19 mg/kg to 126,000 mg/kg. Each of these metals was present at concentrations substantially beneath those reported for lead. For the samples collected in the adjacent zoned residential neighborhood the ratio of these metals to lead was: Cd (0.0021), As (0.011), Cr (0.022), Zn (0.35) and Sb (0.0063).

missing something

## SECTION 6 - SURFACE WATER INVESTIGATION

### 6.01 General

The Site is located in an urban area. The nearest surface water body to the site is the Chain of Rocks Canal located over a mile from the site. No drainage swales or ditches were observed at the site connecting stormwater runoff to this surface water body.

The Granite City engineer's office was contacted concerning flood potential of the site. The site is not located within the 100 year flood plain of the Mississippi River or any other surface water.

For drainage purposes the site can be divided into two areas, the manufacturing area and the slag pile. The manufacturing area is essentially 100% paved with precipitation routed to the sewer system. Catch basins in the paved areas connect to a 24" main running beneath the site with an invert elevation of approximately 404 feet USGS. Figure 3 presents locations for drainage. This elevation is above the ground water table which was in the range of 397 - 400 feet USGS.

The slag pile is not paved and has a very permeable surface composed of case material. Storm water runoff from the pile accumulates in ponded areas south and east of the pile on SLLR property and Tri City Trucking. Run off from the northern portion of the pile is prevented from entering the combined sewer system by the railroad tracks south of 16th Street. This water also ponds until it percolates or evaporates. Section 6.02 presents data on runoff from the slag pile during a heavy storm.

## 6.02 Drainage

Four samples of storm water runoff from the slag pile were collected to evaluate transport of lead by runoff. The samples were obtained from the locations shown on Figure 12. Sampling procedures are detailed in the Sampling Plan (Appendix D of the RI/FS Work Plan).

In all cases for the surface water analyses the data were determined to be usable relative to the overall objectives of the project as presented in Appendix E.

The analytical results for the storm water runoff samples are presented in Appendix I. The unfiltered lead concentration in the storm water runoff samples ranged from 3.0 to 41 mg/l. The reported values are likely a combination of lead solubilized by acid precipitation and eroded particulate lead.

Storm water sample locations and observations of runoff patterns suggest the storm water runoff percolates or evaporates prior to reaching drainage ditches or storm sewer systems. Therefore, storm water runoff serves as a mechanism for eroding materials from the slag pile and SLLR pile and potentially recharging filterable metals to ground water.

## 6.03 Sediment

Samples of storm water sediment were collected at the same locations as the storm water runoff samples. Sediment sampling procedures are outlined in the Sampling Plan (Appendix D-7 of the RI/FS Work Plan).

A review of the analytical data was conducted relative to the QA/QC objectives defined in the QAPP as well as the overall objectives of the project. A summary of the review is presented in Appendix E.

All the data were determined to be usable relative to the overall objectives of the project.

The sediment samples were analyzed for total lead concentration and percent total solids. Appendix I presents the analytical results for the sediment samples. The total lead concentrations ranged from 13,640 to 148,600 mg/kg (dry weight). Observations made during the surface water and sediment sampling effort indicated that transport sediment from the slag pile was limited to property occupied by Taracorp, SLLR, and TCT.

## SECTION 7 - AIR INVESTIGATION

### 7.01 General

Atmospheric lead is known to emanate from many sources, including both point and non-point sources. As indicated by Table 6, by far the largest source of atmospheric lead is the combustion of gasoline. Although the amount of lead emitted by gasoline combustion is decreasing due to the reduction in the usage of leaded gasoline, it remains the most significant contributor to atmospheric lead (USEPA, 1984, Appendix K). In 1981, primary and secondary lead smelting accounted for 1.4 percent and 0.9 percent of the United States atmospheric lead emissions, followed closely by iron and steel production, at 0.8 percent.

The IEPA has established several ambient air monitors near the Site, as presented in Figure 16. These air quality monitors have been used to monitor ambient air quality for lead since 1978. The air investigation presented below utilizes data generated by those monitors and the work conducted by the IEPA as part of the State Implementation Plan to characterize air quality impacts of the Site (IEPA, 1981).

### 7.02 State Implementation Plan

On October 5, 1978, the USEPA promulgated the final designation of a National Ambient Air Quality Standard (NAAQS) of 1.5 micrograms of lead per cubic meter of air ( $\mu\text{g}/\text{m}^3$ ) on a quarterly average basis. Pursuant to the August 7, 1977 amendments to the Clean Air Act (CAA), the State of Illinois conducted a study to determine which areas within the State should be designated attainment, nonattainment, or unclassified with respect to the NAAQS. The lead study was completed

in February 1981. In March 1982, 47 FR 12164, the USEPA approved the State Implementation Plan for Air Pollution Control. All areas of the state were classified as attainment areas, with the exception of the Granite City-Madison-Venice area, which was designated nonattainment. The State was then required to develop a control plan for the area to attain and maintain the NAAQS. In September 1983, the State of Illinois produced a report entitled, "State Implementation Plan for the State of Illinois-Lead (Granite City)" which summarized the results of the 1981 study and introduced a control plan to attain and maintain the NAAQS.

The SIP Report indicated that, based on the data obtained by the air quality monitors and wind rose diagrams, the major sources of atmospheric lead was from the site and adjacent properties. The IEPA also conducted receptor and dispersion modeling to determine control strategies to reduce the air lead concentrations to the NAAQS. The results of the modeling efforts indicated that the blast furnace operation and associated activities were the major contributors to the elevated levels of lead monitored by the air quality monitors. The control strategy selected by the IEPA and negotiated with Taracorp, SLLR, and Tri Cities Trucking included controls on manufacturing as well as paving unpaved areas and cleaning paved areas on a regular basis.

### 7.03 Air Quality Data

Table 7 presents the ambient lead monitoring data at the air quality monitors in Granite City. Excursions of the NAAQS occurred as late as the fourth quarter of 1982 at Roosevelt and Rock Road and 1735 Cleveland. It should be noted that after Taracorp ceased blast furnace

operations in 1983, a reduction in ambient lead was realized. This supports the findings of the SIP concerning lead emission sources.

An increase in ambient lead concentrations during 1984, particularly at the air quality monitor at 15th and Madison, coincides with activity by SLLR. Since blast furnace and SLLR operations shut down early in 1984, air quality has been well below NAAQS. Thus, the waste piles and plant proper are not continuous sources of airborne lead emissions sufficient to cause excursions in the NAAQS for lead at the air monitoring locations in the area.

## SECTION 8 - RISK ASSESSMENT

### 8.01 Risk Assessment Approach

This section outlines the principles and approaches used to evaluate the potential public risks that may exist at the Granite City site. Two general tasks are described: 1) the identification of potential exposure pathways, otherwise known as a qualitative assessment; and 2) the quantitative risk characterization process. The overall risk characterization process is outlined in Figure 17.

#### 8.01.1 Identification of Potential Exposure Pathways

A hazardous chemical may represent human or environmental risks only if humans, animals, wildlife or sensitive ecosystems have the potential to be exposed to the material in sufficient quantity to affect either the health of individuals or the general ecological balance. Exposures to the waste materials can occur in numerous ways. Examples of potential exposure scenarios related to an uncontrolled hazardous waste site include the following:

- Ingestion of surface water or ground water containing solubilized contaminants or ingestion of contaminated surface water sediments or soils.
- Inhalation of volatile contaminants or contaminants airborne in association with particulates.
- Ingestion of biota (e.g. fish) which have bioaccumulated a contaminant released from the waste site.

- Dermal absorption or ingestion of contaminated materials resulting from direct contact with the source of materials at the waste site.

Four basic exposure pathways are considered: the air, surface water, ground water, and direct contact exposure pathways. Each of these exposure pathways may have one or more exposure scenarios associated with them. Although it may be possible to postulate numerous hypothetical scenarios of exposure for each of the basic exposure pathways, a "complete" exposure scenario (i.e. one potentially posing a risk) must include the following components:

1. A waste source and a mechanism of release from it. Examples of release mechanisms include volatilization, wind scour, surface runoff, and leaching.
2. A viable transport mechanism (air, surface water, or ground water) from the waste source to a potential receptor point.
3. A potential receptor population (humans, plants, or animals) or location (i.e. sensitive ecosystem) for a contaminant released and transported from the waste source.
4. An exposure and uptake route (inhalation, ingestion, or dermal absorption); i.e., a mechanism by which the receptor absorbs the contaminant, allowing it to exert its toxic effect.

If any one or more of these components are missing, an exposure scenario is by definition incomplete and, therefore, poses

no risk to health or the environment. Therefore, the first phase of a risk assessment is site and waste characterization and the identification of "complete" exposure pathways. Those scenarios determined to be complete do not at this time indicate that an unacceptable condition exists. The impacts associated with these conditions are further evaluated in the next phase, the "quantitative" assessment.

#### 8.01.2 Risk Characterization Process

As mentioned above, quantitative risk assessment is carried out only for potentially "complete" pathways and their identified scenarios. The first step or "risk characterization" process used in this assessment involves three steps: 1) selection of waste components to serve as indicators of the potential environmental and health significance of the waste; 2) measurement or the prediction of exposure point concentrations at receptor locations; and 3) the comparison of the predicted or measured exposure point concentrations with relevant action levels for the protection of human health to establish whether the waste represents an unacceptable risk to human health and/or the environment.

Indicator chemicals for use in the quantitative analysis are based on a "waste characterization" which considers 1) the nature and history of the waste material and 2) the environmental dynamics and the toxicology of the waste's constituents. Exposure point concentrations are then established for each selected indicator chemical. Site specific data for each indicator chemical and conservative modeling procedures depicting "worst case" scenarios are

used in this process. As a first step in the evaluation of the results, the predicted or measured exposure point concentrations for each indicator species are compared to the relevant action levels for the protection of human health.

The Superfund Amendments and Reauthorization Act of 1986 requires that decision-making regarding remedial action at sites under the authority of the Act be guided by health-based standards or criteria that are legally Applicable or are Relevant and Appropriate Requirements, often termed ARARs. Drinking water Maximum Contaminant Levels (MCL's), National Ambient Air Quality Standards (NAAQS), federally approved state water quality standards developed under the Clean Water Act (e.g. Illinois water quality standards), EPA Health Advisories (SNARL's: Suggested No Adverse Response Levels), and EPA Ambient Water Quality Criteria (AWQC) are used as the relevant ambient concentration requirements for the protection of public health. In those cases where the appropriate contaminant action levels or standards are not exceeded by the concentrations shown by the complete exposure pathways, it can be concluded that the exposure pathway poses no health risk to the receptor.

If, however, the action level is exceeded or if no action level is available, a toxicological assessment is performed with the objective of identifying the magnitude of toxic impact. First, exposures are quantified for all active exposure routes (diet, drinking water, inhalation, dermal absorption) to determine intakes for acute, subchronic, and chronic lifetime exposures of the receptor. For carcinogens, unit risk factors generated from animal test

data using recently promulgated guidelines for performing risk assessments of carcinogens (U.S. EPA 1986), will be combined with intake data to derive a quantitative estimate of the incremental cancer risk. This value is compared to site circumstances, magnitude of the exposed receptor populations, and other factors in order to determine the acceptability of the exposures. For non-carcinogens (e.g. reproductive and developmental toxins, organ and systemic toxins), Acceptable Daily Intakes (ADI's) established by the U.S. EPA or other agencies are located for comparison to estimated exposure levels under acute, subchronic, and chronic conditions. Again, if these values have not been generated, appropriate animal test data will be used if available, determining "no observed effect" levels using appropriate margins of safety (uncertainty factors) in order to determine the potential for health risks to exposed receptors at the estimated intake levels.

It must be understood that action levels are established with the goal of identifying a concentration which, under a variety of circumstances, will not produce an adverse effect on human health or the environment and are not concentrations that will result in a toxic exposure if exceeded. Because of the conservative methodology and margins of safety typically employed to establish these levels, they are not levels that will necessarily produce an adverse effect if exceeded.

## 8.02 Introduction to Qualitative Pathway Assessment

A qualitative exposure evaluation is a determination of the continuity of the waste source, transport routes and receptors at a particular site. The objective of the evaluation is to determine if the three components act together to facilitate transport of wastes from within the site to a particular receptor. An exposure scenario in which all three components are determined to be functioning is termed "complete" and is further evaluated in the quantitative section.

The qualitative exposure assessment is subdivided into three subsections; each concerned with evaluation of one of the components. The first subsection is a description of the waste source. The second subsection evaluates each of the transport routes to determine the manner and extent to which the routes are interacting with the waste source to transport components to offsite locations and receptors. The third subsection identifies each of the potential receptors in the study area and determines whether they can be reached by each of the transport mechanisms.

The product of the qualitative assessment is the identification of specific transport routes and receptors for which a "complete", or potentially complete, pathway of exposure exists. It should be emphasized that this section is concerned only with the identification and documentation of complete exposure scenarios, and does not consider the magnitude of any of the potential exposures identified. The magnitude and significance of those exposures are considered in the quantitative exposure and risk evaluation performed in Section 8.05.

### 8.03 Qualitative Exposure Pathway Assessment

The physical, chemical, and biological characteristics of lead and other metal residues at the Granite City site and surrounding area are discussed in Appendix K. Site-specific elements basic to this risk assessment are reviewed in the following sections.

#### 8.03.1 Source Description

As discussed in section 1.02, particulate lead has accumulated at onsite and offsite locations in the vicinity of the Taracorp facility due to atmospheric emissions produced during many years of lead smelting activities at the site and the accumulation of an exposed onsite slag waste pile consisting predominantly of iron oxides and battery parts with an elevated lead content. Elevated lead residues in soil both onsite and off-site are evident. Rubber battery casings with high lead content may have also been used in some paving/filling operations producing localized areas of offsite contamination. Smelting operations ceased in 1983 and air monitoring data for lead for the past five years have been well below the NAAQS (indicating that emissions of lead from the on-site waste pile are not sufficient to create an exceedence of lead NAAQS at the monitoring locations). Evaluation of exposure will, therefore, focus upon lead-contaminated soil in off-site locations. As presented in Section 8.03.4, several other metals have been detected in Granite City soil and air. The significance of those residues is evaluated in the following sections.

### 8.03.2 Environmental Chemistry and Dynamics

The key elements of the environmental chemistry and transport of lead in the context of urban areas are reviewed in Appendix K and selected physical properties of various lead compounds are listed in Table 16. Briefly, the transport and fate processes of lead in the environment are as follows. Smelting, mining or refining operations release primarily lead oxide ( $\text{PbO}$ ), lead sulfide ( $\text{PbS}$ ), lead sulfate ( $\text{PbSO}_4$ ) and the mixed compound,  $\text{PbO} \cdot \text{PbSO}_4$ . Vehicular emissions consist predominantly of lead halides and double salts with ammonium halides such as  $\text{PbBrCl} \cdot 2\text{NH}_4\text{Cl}$  (USEPA 1984a). As cited in Table 16, inorganic lead compounds have vapor pressures of less than 1 mm Hg at environmental temperatures (USEPA 1984b). Lead compounds are present in the atmosphere adsorbed to particulates (USEPA 1984a). Lead can also be biomethylated, however, forming tetramethyl and tetraethyl lead and these compounds may enter the atmosphere by volatilization (Callahan et al. 1979).

Once in the atmosphere, a variety of reactions can occur that result in the interconversion of lead compounds. For example, lead halides can be photolyzed releasing lead oxide and the free halogens. Other interconversions take place that are not well characterized with the end result being that the predominant form of lead in the atmosphere is lead sulfate with minor amounts of halides (USEPA 1984a). The fate of the tetramethyl and tetraethyl lead is likely to be photolysis to the elemental form and subsequent oxidation to lead sulfate or lead carbonate in the presence of sulfate or carbonate (USEPA 1984b).

Dry deposition and in-cloud rainout are mainly responsible for the removal of lead from the atmosphere (USEPA 1984b). The atmospheric residence time is dependent upon the particle size. It was estimated that 75% of the particulate lead from automobile emissions is removed from the atmosphere in the immediate vicinity of the traffic sources. Tall stack emissions of smaller particles can result in the transport of lead over considerable distances. Particles smaller than 1  $\mu\text{m}$  in diameter may remain airborne for greater than one week (USEPA 1984b).

When lead enters surface water, the predominant aqueous compounds are expected to be the carbonate ( $\text{PbCO}_3$ ), sulfide ( $\text{PbS}$ ) and sulfate ( $\text{PbSO}_4$ ). Lead can also adsorb to organic matter. The result of these reactions will be the partitioning of lead to sediments (USEPA 1984b). Under acidic conditions, however, lead may resist adsorption and precipitation, and remain mobile in the aquatic environment. After incorporation into sediments, lead can be biomethylated to tetramethyl and tetraethyl lead, as noted above. Lead also exhibits bioconcentration factors of 60-200 and may accumulate in aquatic organisms (Callahan et al. 1979).

In soil, reaction with common ions such as sulfate, phosphate and sulfide ions forming lead sulfate ( $\text{PbSO}_4$ ), lead phosphate ( $\text{PbPO}_4$ ), and lead sulfide ( $\text{PbS}$ ), and formation of lead oxide ( $\text{PbO}$ ) is expected to occur. As noted in Table 16, these inorganic lead compounds have low water solubilities, and lead is not, therefore, expected to leach to groundwater in these forms (USEPA 1984b). Lead compounds can also adsorb to and be immobilized by, hydrous oxides of iron and manganese. Reaction with organic

matter can also immobilize lead (USEPA 1984a). These latter reactions will also restrict the soil mobility of lead and decrease its tendency to leach to ground water.

Historically, the use of leaded gasoline as automotive fuel has been the greatest contributor to background levels of lead in the environment (Appendix K). Because of this source "background" lead concentrations in industrialized urban areas tend to be higher than values in suburban or rural areas. The persistence of lead is supported by the soil lead concentrations reported of lead by IEPA, (1983) and those observed during 1986-87 as part of this study.

Localized air and soil contamination as the result of lead smelting in the Granite City study area has been well documented in the past (IEPA, 1983). Atmospheric stack emissions and fugitive emissions both contributed to atmospheric contamination with particulate lead, while fallout of particulate lead has contributed to localized soil lead increases.

#### 8.03.3 Toxicological Profile

Particulate lead compounds can be absorbed into the body via both the respiratory and gastrointestinal tracts with varying degrees of efficiency. For instance, ATSDR (1987) reviews data indicating that lead deposited in the lung is nearly completely absorbed. Dietary lead is absorbed by the gastrointestinal tract to the extent of about 50% in children, and 8 to 15% in adults. Absorption efficiency of ingested lead in dirt and dust has been

estimated as 30% in children. Regardless of uptake efficiency, slow excretion rates cause lead to accumulate in both soft tissues and the skeleton over the lifetime of an individual. The total body burden of lead, and accompanying toxic effects, will be determined by the degree of exposure via the diet and other ingestion routes, and by inhalation of lead in background levels and from localized sources such as the workplace, recreational activities, lead-based paints, and point sources of contamination.

Lead in its various environmental forms (i.e. sulfates, oxides, etc.) is able to combine with a variety of physiologically significant proteins in the body, with resultant effects on structure and function. Little effort has been made to determine the relative toxicity of individual lead compounds or to distinguish among them in determining environmental exposure and toxicity. Of the variety of known toxic effects of lead in humans, perhaps of greatest concern are its neurological effects. As reviewed in Goyer (1986), lead exposure can produce a variety of pathological changes in the central nervous system as well peripheral neuropathy. Subtle encephalopathic effects can occur in children exposed to environmental lead sources. Blood lead levels of 30 to 50 ug/l or lower, in sensitive children have been associated with hyperactivity, decreased attention spans, and small decrements in I.Q. scores. Recent data suggests that levels of 15 ug/dl may be associated with neurobehavioral deficits of concern, for example (as reviewed in ATSDR, 1988). Children appear to be at particular risk because of a relatively greater lead absorption efficiency than older individuals, and a greater probability of exposure to environmental

lead through outdoor play activities and through intentional ingestion of soil (pica). As a result, most lead-related risk assessments center upon toxic potential to exposed groups of children.

Lead exposure is also linked with other forms of systemic toxicity including anemia and other hematologic effects, nephropathy, and reproductive effects. Table 17 lists a number of lowest observed effect levels in humans as a function of blood lead levels. There is no convincing evidence at present regarding the potential carcinogenicity of environmental lead in humans or experimental animals. ATSDR (1988) has reviewed several oral exposure studies with soluble lead salts such as lead acetate in rodents, which indicate an elevated incidence in renal tumors. The data were deemed insufficient for quantitative assessment. Also, the relevance of these data to much lower levels of environmental lead species such as the insoluble oxides is uncertain. A further review of the clinical effects of lead contamination in urban surface soils is given in Appendix K.

#### 8.03.4 Environmental Monitoring

Sections 4 through 7 detail the results of analytical investigations of the waste pile, study area soils, surface and ground water, and air at the Taracorp/Granite City study area.

Quarterly average lead air concentrations in the study area in 1987 were considerably below the national ambient air quality standard of 1.5 ug/m<sup>3</sup>. A combined mean lead value of 0.26 ug/m<sup>3</sup> with a range of 0.16 to 0.43 ug/m<sup>3</sup> were obtained from five Granite City locations in this 1986 survey.

Results of the soil lead survey at the Granite City study area are discussed in depth in Section 5 and summarized in Figures 13, 14, and 15. As Figure 13 indicates, surface soil (0"-3") lead concentrations in residential areas directly south of the Taracorp facility, range from 386 to 769 mg/kg (dry weight). To the north and east of the facility, surface lead values were higher, with several sample sites showing levels of over 3000 mg/kg nearby the facility with a maximum of 4,150 mg/kg observed. Values were generally lower in subsurface (3"-6") soil, with a notable exception of a 14,700 mg/kg value obtained from a far removed site to the east of the facility. This single outlying sample is in all likelihood due to a source of lead unrelated to smelting activities (e.g. paint chip, shot fragment, etc.) and will not be addressed in this risk assessment further.

Hard rubber reclaimed from used batteries was reportedly used as fill and for paving in Venice Township some distance south of the Taracorp facility. The presence of this lead-bearing rubber in selected alleys connecting residential streets was confirmed by visual inspection and by chemical analyses. Surface lead residues of 200 mg/kg to 126,000 mg/kg were detected with most samples in the 2,000 mg/kg to 7,000 mg/kg range.

### 8.03.5 Transport Route Analysis

#### 8.03.5.1 Air Pathway

##### General Method

This section of the transport route evaluation examines the potential for waste materials to be transported to offsite locations in air by the action of wind currents. This section considers the transport of wastes in the volatilized state or as fugitive dusts. In order for the air route to be considered complete, a source of waste materials must exist which is capable of volatilizing into the air above it. Air containing the volatilized waste component must then be capable of entering general wind circulation and be transported toward on- or off-site receptors. In general, for a waste component to represent a source for the air route, it must be exposed to the air and be in a state which allows that component to exert a vapor pressure high enough for the compound to become volatilized.

Volatilization of soil gases is limited to components which can diffuse through the stagnant soil air spaces. Unless accelerated by the movement of gases, such as is often observed during the release of methane from sanitary landfills, this mechanism represents a very low release rate. Thus, a waste material contained within a unit not in contact with air, such as materials covered with solid or other barriers, cannot volatilize and enter the air exposure pathway.

Wind erosion of wastes or solid particles to which wastes are adsorbed can also function to transport wastes in air. This mechanism is facilitated by scouring by winds or the

generation of fugitive dusts by heavy vehicular movement through a waste site. The general requirement for the generation of such "fugitive dusts" is the existence of exposed, friable wastes in an area which is accessible to wind shear or which is travelled upon by heavy machinery.

#### Site Specific

For the purpose of this risk assessment, the vapor pressure of inorganic lead compounds is assumed to be nil. As a result, the environmental occurrence and transport of lead compounds is predominantly as particulate matter and in association with dusts resulting from fossil fuel combustion and various industrial operations. Therefore, discussion of this exposure pathway is limited to inhalation of lead-bearing soils, fugitive dusts, and other particulate matter rather than lead in the vapor state.

*added*  
A variety of activities have contributed to the lead residues monitored in the Granite City study area. First, as in all American urban areas, combustion of coal and fuel oil for generation of heat and electricity, and of greatest significance, of leaded gasoline in transportation has resulted in elevated background levels of lead in air and other media. Reductions in the permissible levels of lead in gasoline, combined with the diminished use of these fuels, has lessened the contribution of this source. However, all these mechanisms increase "background" lead concentrations in soils in industrialized urban areas such as Granite City. In addition,

the various lead smelting activities carried out on the Taracorp facility have contributed lead to the Granite City study area. As previously described in this report, this resulted in ambient air concentrations in excess of the Ambient Air Quality Standard of 1.5 ug/m<sup>3</sup> during smelter operation prior to 1983.

However, when the blast furnace was shut down to reduce lead emissions, lead air residues decreased substantially in the study area, to levels below 0.5 ug/m<sup>3</sup>. With the elimination of this source of atmospheric lead, two additional sources remain in the study area which provide for a potentially functional air exposure pathway; the lead-bearing soils and exposed lead-bearing wastes of the Taracorp facility and exposed soils of surrounding areas which received fallout in the form of particulate lead and other metals from emissions of lead smelting operations. These particulate lead residues may become airborne as the result of wind, traffic and movement of heavy machinery, and recreational activities in exposed soil areas including children's play, and gardening. Based on these possibilities, the air exposure route is concluded to be functional.

#### 8.03.5.2 Soil and Direct Contact Exposure Pathway

##### General Method

There are two possible mechanisms for surface contact exposures to contaminant materials originating at a site. The first mechanism is through direct contact with the exposed

contaminants located at a site, while the second mechanism involves air or surface water-facilitated transport of waste materials from a site to offsite locations followed by direct contact of the wastes at their point of off-site deposition. Both mechanisms require the existence of exposed wastes and or contaminated soils.

Because of the size and water insolubility of environmental lead, lead absorption through the skin is not a significant route of exposure (ATSDR 1987), and will not be considered as a component of direct contact exposure.

#### Site Specific

As discussed in the preceding section on air transport, offsite airborne transport of lead residues from the Taracorp facility in the form of windborne particles, with subsequent off-site direct contact exposure to deposited particles, is currently minimal since the facility ceased smelting operations. This conclusion is supported by air monitoring in the study area. However, operation of the smelting facility for over eighty years has resulted in elevated surface and subsurface soil residues which represent a functional pathway for exposure via direct contact and subsequent ingestion of lead-contaminated soils. Another mechanism which occurred in Granite City is the transport of case material to off site areas of use. This mechanism no longer functions however, the affected areas must be evaluated.

#### 8.03.5.3 Surface Water Exposure Pathway

##### General Method

Exposed waste materials may be transported to off-site receptors by the movement of surface water. For materials that bind readily to soil and other organic particles, surface water-facilitated erosion is the most likely mechanism of transport. For more water soluble materials, transport in the dissolved state can also occur. A surface water exposure pathway may also exist for contaminant-bearing ground water that discharge to surface waters. Materials that persist in surface water present several pathways for exposure including:

1. intentional ingestion with drinking water
2. inadvertent ingestion while swimming
3. inadvertent ingestion of materials that bioaccumulate in food, fish, shell fish, and other aquatic food sources
4. dermal contact and inhalation (of volatiles) during bathing or showering
5. acute, subchronic, and/or subchronic exposure of aquatic organisms

##### Site Specific

The surface water pathway was determined to be non-functional based on the absence of surface waters in the study area. Observed runoff away from the area of the waste pile on the site is limited to the property of TCT, SLLR and Taracorp. In addition, the absence of evidence that ground water containing lead was moving off the site supports

this conclusion. This pathway, therefore, will not be considered further.

#### 8.03.5.4 Ground Water Exposure Pathway

##### General Method

Transport of waste materials towards receptors via the ground water pathway requires the existence of waste materials with sufficient water solubility to become dissolved by and transported with ground water, a mechanisms by which surface infiltration and/or ground water can come into contact with and leach out components of the waste material, and a mechanism for the movement of the leachate into and along with ground water downgradient from the site. Each of the above characteristics acts to promote or limit the movement of waste constituents from the point of deposition to offsite locations. Human exposure via this route requires use of ground water containing site indicators. Most commonly, exposure may occur by:

1. ingestion of drinking water
2. dermal contact and inhalation of volatiles while bathing or showering.

##### Site Specific

##### Ground Water

The ground water route was determined to be incomplete based on the absence of ground water wells known to be used as drinking water sources. In addition, recharge of site-related ground water to surface water other than to the

Mississippi River is not probable. This pathway, therefore, will not be considered further in the Risk Assessment.

#### 8.04 Identification of Human Receptors and Exposure Routes

This section reviews each of the transport routes identified in the previous sections as functional and evaluates each route for completeness relative to human receptors identified in the study area. The two transport routes determined to be functional were the air exposure route and the direct contact exposure route.

##### 8.04.1 Air

The air exposure route was determined to be functional due to the presence of friable lead-bearing soils and respirable dusts both on- and offsite which can contribute to the total burden of lead exposure. Low levels of other metals have also been detected in between air and soil. Since the time that the Taracorp facility ceased smelting operations, the major contributing source of airborne lead exposure, stack emissions of lead-bearing particulates from the smelting operations, is no longer functional as borne out by the substantial decline in the lead content of ambient air in the study area. Further, reductions in the use of leaded gasolines have reduced airborne exposures from non-site related sources.

The primary air-mediated mechanism for exposure of Granite City residents to lead and other metals will be inhalation and subsequent absorption of soil particulates and dusts. Mechanisms that could transport lead residues to the human breathing zone include wind, traffic, walking, children's play and other

recreational activities. The air pathway will be considered in the quantitative section of this risk assessment as one of several sources of exposure.

#### 8.04.2 Direct Contact

The direct contact route was evaluated as functional based upon the existence of elevated surface lead residues both on the site of the Taracorp facility as well as soils of nearby neighborhoods to the north and east of the site. Another area, less than five miles to the south of the site in Venice Township, also has elevated soil lead residues within residential alleyways, reportedly from use of hard rubber from battery cases for fill and alley paving. The most likely exposure scenario for offsite Granite City residents will be direct contact with exposed soils during outdoor activities, followed by ingestion and systemic absorption of associated lead residues. The most likely candidates for exposure via this route include children playing in non-vegetated areas, and people engaged in other recreational activities such as gardening and softball, baseball and other outdoor sports.

#### 8.04.3 Summary and Conclusions

The results of the qualitative exposure assessment of the study area indicate two scenarios for potential human exposure exist and are "complete". These pathways are 1) the airborne route, with lead-bearing soil particulates and dusts transported from friable soils on the Taracorp site to offsite locations for subsequent inhalation; 2) the direct contact route, with exposed

soils previously contaminated with lead from particulate fallout from smelting emissions in previous years providing a source for ingestion of lead residues. These "complete" exposure pathways will be further evaluated in section 8.05 in the quantitative risk assessment to evaluate the magnitude of risk by each.

## 8.05 Risk Assessment

### 8.05.1 General Introduction to Quantitative Techniques

A comprehensive endangerment or risk evaluation is a procedure by which exposure scenarios identified as "complete" in the qualitative assessment are evaluated relative to the existence, magnitude, environmental fate, and toxicological impacts of waste components released from the site and transported to receptors. In this section, rates of exposure of receptors to the site-related indicator contaminants by the airborne and direct contact exposure scenarios formulated in the qualitative assessment are calculated and evaluated as to their significance.

A major portion of the evaluation is based upon the results of quantitative chemical residue investigations of air, soils and ground water at the study site. The observed residues are interpreted on the basis of considerations of the physical, chemical, and biological factors limiting their releases and controlling their movement and fate at offsite locations.

## 8.05.2 Estimates of Release and Exposure Rates

### 8.05.2.1 Estimates of Airborne Exposures

The qualitative section of this assessment has established that the air route represents a complete exposure pathway for Granite City residents in areas adjacent to the Taracorp site, and in Venice Township where battery rubber from the site was used in paving alleys. Air analyses for Granite City in 1987 gave a mean quarterly value of 0.26 ug/m<sup>3</sup> for lead. Mean national values for urban areas were not available for 1987. However, the value reported for East St. Louis was 0.33 ug/m<sup>3</sup>. These values, far below the national standard of 1.5 ug/m<sup>3</sup>, may therefore reflect background levels to be expected of American urban areas since restrictions were placed on the production and use of leaded gasoline (previously the predominant source of environmental lead) in the early 1980s. Since Granite City atmospheric lead levels declined significantly with the closing of the smelter in 1983, it may be inferred that exposed wastes and contaminated soils on- and offsite are not contributing significantly to general ambient Granite City atmospheric lead. For the purpose of this risk assessment, the 1987 quarterly mean (five sites) of 0.26 ug/m<sup>3</sup> lead will be used for exposure assessment.

Table 18 summarizes the exposure rates and associated risks from inhalation of inorganics monitored in Granite City air in 1987. Using an adult inhalation rate of 20 m<sup>3</sup>/day, 70 kg adult body weight, and assumption of lifetime exposures,

daily exposure rates were derived and integrated with the acceptable daily intake (ADIC) for lead, or with the cancer potency factors for the inhalation carcinogens arsenic, cadmium, and chromium to derive an estimate of chronic or excess carcinogenic risk via the air pathway. Because available monitoring data do not differentiate between non-carcinogenic trivalent chromium and carcinogenic hexavalent chromium all air chromium residues were assessed as hexavalent chromium. This will somewhat overstate the risk estimate. As no beryllium was monitored, it was not considered in the assessment.

Exposure to lead via inhalation yielded a hazard index (ratio of exposure rate to ADIC) of 0.17, below the level of 1 constituting a level of concern. The contribution of this exposure pathway of lead to overall chronic toxicity is discussed in the following section. Cancer risk estimates for individual metals range from  $2.6 \times 10^{-4}$  (chromium) to  $1.6 \times 10^{-5}$  (cadmium), with a total estimate of lifetime cancer risk of  $2.8 \times 10^{-4}$ . The contribution of this pathway to overall cancer risk is also evaluated in the following section.

#### 8.05.2.2 Estimates of Direct Contact Exposures

The qualitative section of this assessment has established that the direct contact pathway represents a complete exposure route for Granite City residents in areas adjacent to the Taracorp facility, and for residents of Venice Township where reclaimed battery rubber was used to pave alleys in residen-

tial areas. Direct ingestion of lead-bearing soil is generally held to be a major route of exposure to that element, particularly in children.

The results of a survey of soil residues of metals in Granite City in addition to lead are summarized in Table 19. In order to rank the overall contribution of these metals to chronic health risks, a comparison was made of the exposure rate from ingesting 100 mg of soil at the mean observed concentration observed to intake levels which have been suggested as being acceptable (i.e. reference doses, chronic acceptable daily intakes). This soil ingestion rate is suggested by U.S. EPA (USEPA 1986b) for initial screening of site indicators and does not reflect ingestion rates likely for lifetime exposures on a site-specific basis. The hazard index ranking indicates that lead dominates concerns for chronic toxicity of metal contaminants in soil. The lead hazard index exceeds the threshold for further evaluation of one by a factor of nearly three-fold, and is forty-fold greater than the hazard index of the next closest contaminant, antimony. Furthermore the sum of the hazard indices of cadmium, chromium, zinc, and antimony is only 0.108. Because of the relative unimportance of these metals compared to lead, and because the concentrations observed were within or only slightly in exceedence of ranges typically observed in virgin soils, lead will be selected as the site indicator compound for further evaluation as a chronic soil contaminant.

Arsenic in soil will be evaluated for carcinogenic risk according to the exposure scenario developed in the following discussion.

Therefore, a three-pronged approach has been employed in assessing the potential risks associated with lead exposure in the Granite City area. First, a site-specific risk assessment conducted by the Illinois Environmental Protection Agency (IEPA) is reviewed and evaluated. Secondly, ingestion and inhalation exposures to lead are estimated and compared to acceptable daily intake levels for lead. Finally, risks are estimated using literature derived correlations between soil lead concentration and blood lead concentrations.

#### IEPA Blood Lead Survey Approach

A quantitative risk assessment was performed on the Granite City study area in 1982 by the IEPA (Exhibit D). The IEPA reported a monitoring survey of air, water, soil, and blood lead of the Granite City area and its residents. This survey showed a marked elevation of soil lead levels and atmospheric lead. The Taracorp facility was performing secondary lead smelting at the time of sampling. Neither site ground water nor vegetables grown in lead contaminated soil showed lead levels of concern.

Forty-six area children aged six years or less were tested for blood lead and a lead-related clinical parameter, FEP (free erythrocyte protoporphyrin), and the results "...provided no evidence that there are lead-related health problems present in the area." The Illinois Department of

Public Health, which conducted the survey, considered a blood level of 30 ug/dl in combination with an FEP level of 50 ug/dl to constitute a level of endangerment. No such cases were found in a total of 97 area residents, including the 46 area children "...even though one or two (cases) could have normally occurred in a sample of 46 urban children."

The average blood lead level of the children sampled was 10 ug/dl, and blood FEP averaged 17 ug/dl. The IEPA also conducted exposure assessments for various pathways, including ingestion of soil by children playing in exposed soil areas, using a range of ingestion estimates (page 35, Exhibit D). The IEPA concluded, on the basis of the 1982 blood survey and two previous blood surveys in the area, that "...a major risk to public health is unlikely to exist provided that ambient air quality levels do not exceed the NAAQS and that routine personal health and hygiene measures are followed." (page 49, Exhibit D).

In evaluating the IEPA risk assessment and in independently estimating the degree of risk to receptor populations, several key factors must be considered;

1. The IEPA blood survey of 1982 was conducted while lead air levels exceeded the NAAQS. Thus, even while the air exposure route was formerly a much greater contributor to lead exposure than at the present time, due to the smelting activities at the Taracorp site which ceased in 1983, residents' blood levels were less than those currently thought to constitute a risk to public health.

2. The two principal means for environmental dissemination of lead at the study area during the 1982 study, smelting and use of leaded gasoline, have been almost totally eliminated. This reduces current exposure in two ways. Obviously, direct inhalation exposure has been reduced as verified by air monitoring in Granite City. In addition, dietary exposure from particulate lead deposited on articles of food should also have been reduced since 1982.
3. IEPA worst case estimates for soil lead exposures to children in the study area assume that contaminated, unvegetated soils are commonplace and the location of daily youth activities. In contrast, visual inspection of the neighborhoods surrounding the Taracorp facility found them not to contain play grounds or schools and to be generally vegetated or paved in non-industrial areas. Even given the propensity for small children to locate areas of exposed soils and mud for play, the probability for this to occur on a daily basis as assumed in the IEPA report seems remote for the Granite City area.
4. The sample size, 97 area residents of which 46 were children, was not large enough to establish a statistical case that no persons in the study area have unacceptably high blood lead concentrations.

5. The blood lead survey was conducted during the autumn, a period of lesser out door activity in the community than the middle of summer. Therefore, blood lead levels may have been higher in the summer. If this did occur, any observed summer increase disappears quickly, because the values were at acceptable concentrations by November and December 1982.

In summary, blood lead analyses conducted on residents of Granite City in 1982, provide real data necessary for evaluating risks in the vicinity of the site under environmental lead exposures higher than present conditions. Blood lead analyses did not indicate an unacceptable risk at that time for the 97 people tested.

A 1983 blood lead survey of residents in Venice Township was conducted by the Illinois Department of Public Health (Exhibit D). Of 136 adults and children tested, 72% had blood lead levels of 10 ug/dl or less, while only one individual exceeded 25 ug/dl.

#### Acceptable Daily Intake Approach

The US. EPA (1986) presented a chronic daily acceptable intake (AIC) for ingested lead of 1.4 ug/kg/day, and of 0.43 ug/kg day via inhalation. The ingestion value appears to be derived from the exposure rate of a 70 kilogram adult consuming two liters per day

of water containing 50 ug/l of lead (the current lead MCL). In August 1988 the EPA proposed revising the acceptable lead concentration in drinking water from 50 micrograms/liter at the point of use to 10 micrograms/liter at the point of use. This reduction in acceptable lead intake via drinking water may result in a change in the AIC for ingested lead. In addition, CDC is considering a reduction in acceptable blood lead concentration from 25 ug/dl to 15 ug/dl.

To establish an additional margin of safety, this risk assessment will use an assumed AIC for ingestion of lead 0.84 ug/kg/day, or 60% of the published value. This value is comparable to an ADI of 0.69 ug/kg/day derived by Marcus (1984) using a published blood lead/drinking water lead correlation approach, focusing on 15 ug/dl as an apparent no observed adverse effect level for lead. This ADI established by Marcus (1984) equated lead intake with absorbed lead, since it utilized data on water lead residues which are well absorbed compared to other dietary lead sources.

The daily intake of lead can be estimated under worst case conditions by assuming that an individual directly contacts lead-containing soils over an extended period of time and that such contact results in inadvertent ingestion and assimilation of the soil, and subsequently, lead. Such an ingestion rate might be incurred by an individual who, as a child, plays in

exposed soils and in later life continues to contact soils through recreational activities such as sports and gardening or through construction work. Soil ingestion rates on a case-specific basis are largely a matter of conjecture, although several recent studies provide some guidance in this area.

LaGoy (1987) has reviewed the available literature and concluded that the following are reasonable estimates of soil ingestion as a function of age: 0-1 years (10 kg average weight), 50 mg/day; 1-6 years (15 kg weight), 100 mg/day; 6-11 years (30 kg weight), 50 mg/day; and over 11 years (70 kg), 50 mg/day. Calabrese et al (as presented in the Superfund Exposure Assessment Manual, U.S. EPA 1988) has suggested the following typical soil ingestion rates as a function of age: 0-9 months, 0 mg/day; 9-18 months, 50 mg/day; 1.5 to 2.5 years, 200 mg/kg/day; 3.5 to 5 years, 50 mg/day; and 5 to 18 years, 10 mg/day. As an overall average, both U.S. EPA (1986) and U.S. EPA (1988) have suggested 100 mg/day as an overall average for children. This value will be adopted for this risk assessment over the period of 9 months of age to 18 years. For adults (18-70 years) a rate of 10 mg/day is used. To reflect an upper bound exposure rate involving intentional soil ingestion (pica), a rate of 1000 mg/day between the ages of 9 months and 5 years and ingestion of 50 mg/day for the remainder of the lifetime is used.

The exposure assessment will include the following additional assumptions:

1. Exposure will occur 5 times weekly, 26 weeks per year for a 70 year lifetime.
2. Available values of the oral ADI for lead were set for water residues of lead which are relatively well absorbed compared to other dietary sources. Soil lead will be incompletely absorbed relative to residues in water or air. In the Toxicological Profile for lead, ATSDR (1988) a value of 30% absorption of soil-bound lead for children is presented. Dietary lead from food intake appears to be absorbed to the extent of 50% in children and approximately 10% in adults. Because of the considerable variation in the absorption rate as a function of age, fasting, and other factors (ATSDR, 1988) an absorption factor of 50% will be used for all dietary intake estimates.

The overall average daily soil ingestion can be determined for the EPA suggested scenario as:

$$\begin{aligned} & (100 \text{ mg/day} \times 130 \text{ days per year} \times 18 \text{ years}) \\ & + (10 \text{ mg/day} \times 130 \text{ days per year} \times 52 \text{ years}) \\ \text{or } & 234,000 \text{ mg} + 67,600 \text{ mg} / 25550 \text{ days in lifetime} \\ & = 11.8 \text{ mg/day} \end{aligned}$$

For the upper bound worst case, the daily average soil ingestion is estimated by the same approach to be 38.4 mg/day.

The following relationship may be used to estimate a soil level of lead which may be acceptable for long term ingestion:

$$\frac{\text{Acceptable Soil (ug/g)}}{\text{Lead}} = \frac{\text{Acceptable Daily Intake via soil (ug/kg/day)} \times 70 \text{ kg}}{\text{gram soil ingested/day} \times 0.5 \text{ absorption factor}}$$

At present, U.S. EPA does not offer a verified reference dose for lead, but U.S. EPA (1986) offers a chronic acceptable daily intake (ADI) for the oral route of 1.4 ug/kg/day for long term exposure. To provide an additional margin of safety an adjusted value of 0.84 ug/kg/day will be assumed based on the proposed reduction in acceptable blood lead concentration, from 25 micrograms/dl to 15 micrograms/dl.

An estimate of a soil specific ADI follows. ATSDR (1988) presents data on baseline lead intake of an adult male of 49.7 ug/day in food, water and beverages, and dust, or 0.71 ug/kg/day. Correcting with a 50% gastrointestinal absorption efficiency for food (ATSDR, 1988, data for children, less for adults) the actual non-soil exposure rate is 0.36 ug/kg/day. In addition, 0.07 ug/kg/day is absorbed via inhalation assuming complete absorption of inhaled lead. The total absorption is thus 0.43 ug/kg/day. Subtracting this value from the oral ADI gives a soil-specific acceptable daily intake of 0.41 ug/kg/day for lead.

Substituting this value into the above equation for the two scenarios:

$$ASL = \frac{70 \text{ kg} \times 0.41 \text{ ug/kg/day}}{0.0118 \text{ g soil/day} \times 0.5} = 4864 \text{ ug/g} = (4864 \text{ mg/kg})$$

$$ASL = \frac{70 \text{ kg} \times 0.41 \text{ ug/kg/day}}{0.038 \text{ g} \times 0.5} = 1510 \text{ ug/g} = (1510 \text{ mg/kg})$$

Based on these calculations the soil concentration at which the ADI will be exceeded is approximately 4864 mg/kg using suggested EPA values and 1510 mg/kg using upper bound worst case conditions.

Using the soil exposure scenario developed above for lead, risks of excess cancer incidence due to arsenic ingestion can be estimated as follows. For the U.S. EPA suggested scenario, ingestion of 11.8 mg soil per day containing the site mean value of 16.5 mg/kg arsenic gives a daily lifetime arsenic intake rate of  $1.95 \times 10^{-4}$  mg/kg/day. Using a cancer potency factor of  $1.5 (\text{mg/kg/day})^{-1}$  yields a cancer risk estimate of  $2.9 \times 10^{-4}$  for the oral route. Adding the sum of carcinogenic risks estimated for the airborne route from arsenic and the other carcinogenic metals measured, a total cancer risk estimate of  $3.3 \times 10^{-4}$  is obtained. It must be noted that the arsenic concentrations observed in commercial/residential areas are all within background ranges (1-50 mg/kg) reported by Lindsay, 1979 and (0.1-80 mg/kg) reported in ATSDR, 1987. The apparent national average for arsenic in soil was reported as 5-6 mg/kg in ATSDR, 1987.

### Soil Lead-Blood Lead Correlation Approach

A variety of studies have sought to determine the contribution of lead contaminated soil to blood concentrations, as reviewed in Appendix K. Perhaps the most appropriate for use in this risk assessment is the report of Stark et al. (1982), which, using data collected in an urban area of the U.S., estimated that for each 1000 ppm of soil lead above background, blood lead level in children increased approximately 2 ug/dl. This value was suggested by the U.S. EPA (1984) as a reasonable value.

Opinions vary regarding levels of lead in blood which constitute cause for concern. Recent trends are downward as studies reveal that neuropathic effects of lead may occur in children at lower intake levels than previously thought. For instance, The U.S. Food and Drug Administration considers blood lead levels of 20 ug/dl or less as indicative of background exposure to lead (Exhibit E, ref. 1), and the U.S. Environmental Protection Agency has previously considered 30 ug/dl of blood lead to be a safe level for children (Appendix K, ref. U.S. EPA, 1977). Previously, however, the National Center for Disease Control has determined levels equal to or greater than 25 ug/dl to be a cause for concern (Exhibit E, ref. 2) but it is now considering a level of 15 ug/dl instead. Therefore, this value will be adopted as an "action level" for the purposes of this risk assessment.

A complete exposure pathway to surface soil containing 3170 ppm lead exists (the maximum value observed in commercial/residential zoned area surface soils). Assuming each 1000 ppm of lead in soil contributes an increment of 2 ug/dl to the blood, it is estimated that a blood lead increase of 6.3 ug/dl could be achieved.

Since restrictions were placed on the use of leaded gasoline, the blood lead concentration nationally is approximately 10 ug/dl. The addition of 6.3 ug/dl to this national average could increase the blood lead concentration above 15 ug/dl. However, during 1982 the Granite City average was 10 ug/dl. This may further substantiate that areas of exposed, lead-bearing soils are not generally prevalent in the study area.

Recycled hard rubber from scrapped battery cases was used for fill and paving material in back alleys of residential neighborhoods in Venice Township. Limited sampling in these areas revealed surface levels of lead ranging from 200 to 126,000 ppm, with five additional samples in the range of 2,260 to 7,490 ppm. Visual inspection of the area showed chips of rubber present on the surface of the alleys and that the alleys could be used by children for play. The range of analytical values obtained suggests that the contamination may be heterogenous in the area, making it difficult to select a representative average value for lead exposure at this

site. Using the highest value reported results in a blood lead increase of 252 ug/dl, clearly an unacceptable level of risk in areas potentially used by the public. It should be noted, that there may have been an isolated sample in the fill areas and not frequented as a regular play area because blood lead levels in Venice did not indicate this type of range.

The Center for Disease Control (Preventing Lead Poisoning in Children, January 1985) stated, "In general, lead in soil and dust appears to be responsible for blood lead levels increasing above background levels when the concentration in the soil or dust exceed 500-1000 ppm." This statement is consistent with the results of the literature review as a difference of 1 to 2 ug/dl in blood would be difficult to detect given the varied sources of lead exposure. It should be noted that this statement is based on detectable changes from background, not acceptable levels from a site specific risk assessment perspective as required by EPA 1986b.

Unit good

#### 8.06 Summary and Conclusions

The qualitative exposure evaluation of the Granite City study area determined that lead residues existing at the soil surface could potentially result in human exposures via inadvertent soil ingestion and, to a lesser extent, by inhalation of dusts. On this bases, other direct contact/ingestion pathway and air exposure pathways are concluded to be complete. The ground water pathway is not complete since there are

no known drinking water wells in the vicinity, so the ground water pathway does not represent any potential risks to residents of the area around the site. The surface water pathway was determined to be non-functional due to the absence of surface water near the site and no drainage ditches connecting stormwater runoff to surface water bodies.

The quantitative risk assessment of the complete exposure scenarios at the Granite City study area was conducted in a three-pronged approach. First, available monitoring data for blood lead content of area residents was compared with values considered by health agencies to constitute a level of concern. Secondly, a hypothetical worst case scenario was analyzed, which assumed chronic lifetime contact with exposed site soils. Finally, an available published study was utilized which provides a basis for estimating incremental increases in blood lead due to exposure to increasing levels of soil lead. The results of all three analytical approaches indicate that the soil lead and air residues present in the Granite City study area do not represent an unacceptable risk to public health. Higher exposed surface lead residues exist in areas of Venice Township which, under chronic exposure conditions, could impact human health. However, a survey of blood lead content in residents of this area did not produce evidence of such a health impact, suggesting that significant exposure to these residents is not occurring.

## SECTION 9 - REMEDIAL RESPONSE OBJECTIVES

### 9.01 General

The Statement of Work identifies, in Task 4, several items relative to remedial technologies and alternatives that are to be presented in the RI Report. Several of the requirements of Task 4 are inconsistent with the current NCP, EPA guidance on RI/FS's based on the current NCP (USEPA, 1985), and EPA guidance on SARA and the proposed revisions to the NCP (USEPA, 1986). These inconsistencies specifically relate to the screening of remedial technologies, and the screening and evaluation of remedial alternatives, which are major considerations of the FS rather than the RI. While the intent of Task 4, i.e., to "... ensure that site investigations will develop a data base adequate for the evaluation of alternatives during the feasibility study," was incorporated into the planning and execution of the RI, the FS will include the screening of remedial technologies and screening and evaluation of remedial alternatives. Therefore, to be consistent with current regulations and EPA guidance which supercede the Statement of Work, the FS Report will document the screening of technologies and screening and evaluation of alternatives.

The RI, by defining the nature and extent of contamination on and around the site, forms the basis for the development and evaluation of Remedial Alternatives during the FS. In addition to identifying the nature and extent of contamination at the site, remedial response objectives, and preliminary remedial technologies are outlined during the RI.

The evaluation completed as part of the RI identified existing conditions and assessed risks associated with those conditions. The

response objectives are set at environmental concentrations which protect human health and the environment. Response objectives may address both components of the risk assessment: environmental concentration and receptor contact. The response objectives set numerical values for concentrations of substances within each environmental matrix under a selected exposure scenario. Consequently, the numerical concentrations may not be the same as values used at other facilities where environmental conditions and exposure scenarios differ.

In addition to meeting response objectives, each alternative considered must be evaluated relative to applicable or relevant and appropriate requirements (ARAR). Applicable requirements are defined in 40 CFR Part 300.6 as "...those Federal requirements that would be legally applicable, whether directly, or as incorporated by a Federally authorized state program, if the response were not undertaken pursuant to CERCLA Section 104 or 106." Also in 40 CFR Part 300.6, relevant and appropriate requirements are defined as "...those Federal requirements that, while not "applicable," are designed to apply to problems sufficiently similar to those encountered at CERCLA sites that their application is appropriate. Requirements may be relevant and appropriate if they would be "applicable" but for jurisdictional restrictions associated with the requirements." SARA requires that state requirements must be more stringent than Federal requirements if they are to be utilized as applicable or relevant and appropriate requirements (ARARs). If no Federal or State requirement pertains to remediation then a risk assessment is used to compare remedial alternatives. In developing remedial response objectives chemical specific ARAR's have

been used to establish numerical response criteria in accordance with EPA guidance published August 27, 1987 (52 FR 32496).

#### 9.02 Remedial Response Objectives

Once the nature and extent of contamination have been defined and the risks to public health and the environment posed by the contamination have been identified, the objectives of the remedial response can be outlined. Sections 3 through 7 of this Report presented the findings of the RI, including the nature and extent of contamination in each of the environmental matrices sampled. Section 8 presented the site-specific risks posed by the concentrations of materials identified in each of the matrices. The Remedial Response Objectives for the Granite City site are presented in Table 10 for each complete exposure pathway posing a risk to public health and the environment.

##### Soil

A surface soil lead concentration was identified in the Risk Assessment (Section 8) as being protective of human health within residential areas. The response objective for these areas is a surface soil concentration which is protective of human health under upperbound worst case assumptions. Present usage of commercial zoned areas is inconsistent with worst case assumptions included in the Risk Assessment. However, portions of these areas could be regularly frequented; therefore, the same criteria will be applied to soils in these areas. Heavy industrial zoned areas are not subject to the same usage; therefore, the response objective for these areas is to be protective of human health under

U.S. EPA suggested exposure conditions as defined in Section 8.05.2.2. Potential ARARs to be considered during the development of remedial alternatives include the air standards identified in Table 8.

#### Waste Piles

The waste piles consist of various process wastes resulting from secondary lead smelting operations, including slag, dross, matte, grid metal, and plastic and rubber battery cases. The risk assessment based response objectives for the surface concentration of the waste pile located in a limited access area is the same as for heavy industrial zoned properties. Potential ARAR's to be considered in the development of remedial alternatives for the waste piles are presented in Table 8. The major components within the waste pile are blast furnace slag/matte and battery case material which have been determined to have hazardous characteristics pursuant to 40 CFR 261. Consequently, potential ARARs for this material are those associated with the management of hazardous wastes.

#### Ground Water

The response objective for ground water is based on Illinois ground water standards, however, these objectives may be modified to reflect ground water quality entering the site. The risk assessment concluded that the ground water pathway was incomplete because potable supply users were not identified. However, for purposes of addressing the remote possibility that a supply

well would be installed in spite of the presence of municipal water supplies, the selected objectives are based on the Illinois general ground water quality standards.

The "background" water quality did demonstrate total dissolved solids and manganese at concentrations equal to the Illinois ground water quality standards. The response objective is to meet Illinois standards or match "background" quality if it exceeds the published standards.

#### Air

The response objective is to maintain air quality at the 1.5 mg of Pb/m<sup>3</sup>. Remedial approaches must address the potential ARARs presented in Table 8.

## SECTION 10 - PRELIMINARY REMEDIAL TECHNOLOGIES

### 10.01 General

The Risk Assessment, presented in Section 8, indicated that certain areas and environmental matrices will require remediation due to concentrations of lead and other heavy metals above the defined response objectives. These include the waste piles, on-site surface soils, and certain off-site areas.

Alternatives for the remediation of these areas are to be developed and evaluated in the FS. The FS procedure is one in which, initially, general response actions are identified to address each of the site problems and remedial objectives. The next step in the FS procedure is to identify technologies associated with each general response action which could be potentially applicable. The technologies are then screened to eliminate inapplicable and infeasible technologies from further consideration. The remaining remedial technologies are then grouped into remedial alternatives which address all the site problems and pathways. The remedial alternatives are screened to eliminate alternatives that are not suitable for further consideration. The remaining remedial alternatives are then evaluated in detail. Based on the detailed evaluation of alternatives, one remedial alternative is selected and recommended for implementation.

The FS process is very involved and requires careful consideration at each step. Of particular importance is the initial step of selecting remedial technologies that are potentially appropriate based on the knowledge of site conditions. This step is critical as it lays the foundation for the FS. It is appropriate, therefore, to introduce in the RI

Report a list of preliminary remedial technologies which will be among those considered in the FS.

#### 10.02 Preliminary Remedial Technologies

Response technologies may address a cause of a problem or an effect. For example at the site the slag pile is a source which contains tons of lead and iron. An effect of such a source would be concentrations of lead or iron in the ground water above standards. If the effect is causing an unacceptable risk, then the effect is typically addressed, however, the preferred approach is to address the source (cause).

Lead or iron can not be destroyed, therefore the focus of the technology assessment is to manage the lead in a manner that protects human health and the environment. The preferred approach is to recycle/recover the lead and render the residue non hazardous for all metals of concern. Advantages of this approach are substantially reduced if residuals must still be managed as hazardous wastes to be protective of human health and the environment. If recycle/recovery is not technically or economically feasible then technologies which render the waste permanently less hazardous become more important. Selected fixation processes have been developed which take EP-Toxic materials and change the characteristics by chemical fixation such that lead is not available to impact human health or the environment. Other technologies which are pertinent to lead contaminated soils are various containment methods. These technologies are based on preventing contact with the lead, thus being protective of human health and the environment.

The list of preliminary remedial technologies to be included in the FS is presented as Table 11. The preliminary remedial technologies are presented in the table along with their respective general response action.

These technologies focus on sources of lead within the slag pile, fill areas, and soils. Based on data generated as part of this RI investigation remedial technologies addressing surface water and air pathways will only be considered if a remedial alternative selected for evaluation will result in releases from the remedial areas by surface water or air routes.

Respectively submitted,

O'BRIEN & GERE ENGINEERS, INC.



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# Tables

TABLE 1

## WELLS IN VICINITY OF GRANITE CITY SITE

<u>Well No.</u>	<u>Reputed Owner</u>	<u>Use</u>	<u>Well Depth (feet)</u>	<u>State of Illinois Number*</u>
1.	Granite City Steel Co.	Not used	N/A	24.1c1
2.	Granite City Steel Co.	Not used	N/A	24.1c2
3.	Dressed Young Dairy	Industrial Supply	110	24.3h
4.	General Steel Coating Co.	Industrial Supply	114	24.5e
5.	General Steel Coating Co.	Industrial Supply	N/A	24.6c
6.	Celotex Company	Industrial Supply	110	25.8b
7.	East St. Louis Drainage and Levee Dist.	Relief Well	59	26.6b
8.	East St. Louis Drainage and Levee Dist.	Relief Well	55	26.7d
9.	East St. Louis Drainage and Levee Dist.	Relief Well	69	26.8e
10.	East St. Louis Drainage and Levee Dist.	Relief Well	55	26.8h
11.	Granite City Steel Co.	Not used	N/A	19.3g1
12.	Granite City Steel Co.	Not used	N/A	19.3g2
13.	Granite City Steel Co.	Not used	N/A	19.7b
14.	Granite City Steel Co.	Not used	N/A	19.8f1
15.	Granite City Steel Co.	Not used	N/A	22.1c
16.	East St. Louis Drainage and Levee Dist.	Relief Well	59	22.1c
17.	East St. Louis Drainage and Levee Dist.	Relief Well	59	23.6c
18.	East St. Louis Drainage and Levee Dist.	Relief Well	60	23.7c
19.	East St. Louis Drainage and Levee Dist.	Relief Well	65	13.8g

TABLE 1

WELLS IN VICINITY OF GRANITE CITY SITE  
(Continued)

<u>Well No.</u>	<u>Reputed Owner</u>	<u>Use</u>	<u>Well Depth (feet)</u>	<u>State of Illinois Number*</u>
20.	Union Starch & Relief Co.	Abandoned	115	13.3a
21.	N/A	N/A	N/A	13.1b3
--	N/A	N/A	N/A	13.1b4
22.	N/A	N/A	N/A	13.2b
23.	N/A	N/A	N/A	13.4a
24.	N/A	N/A	N/A	13.5a
25.	N/A	N/A	N/A	24.3h2
26.	N/A	N/A	N/A	24.5f
27.	N/A	N/A	N/A	24.6d
28.	N/A	N/A	N/A	24.7c
29.	N/A	N/A	N/A	25.8h
30.	N/A	N/A	N/A	18.8a1
--	N/A	N/A	N/A	18.8a2
31.	N/A	N/A	N/A	19.3h
32.	N/A	N/A	N/A	30.6e
33.	N/A	N/A	N/A	14.3c
34.	N/A	N/A	N/A	14.1f
35.	N/A	N/A	N/A	14.4b
36.				14.2d

Source of Information:

- (1) Kohlhasse, R.C., 1987, Ground Water Levels and Pumpage in the East St. Louis Area, Illinois, 1981-1985: Circular 168 Illinois State Water Survey, Champaign, Illinois, 40 p.

Source of Information: (Continued)

- (2) Schict, R.J. and Jones, E.G., 1962, Ground Water Levels and Pumpage in East St. Louis Area, Illinois, 1890-1961: Report of Investigation 44, Illinois State Water Survey, Urbana, Illinois, 39 p.
- (3) Baker, W.H., 1972, Ground Water Levels and Pumpage in the East St. Louis Area, Illinois: Circular 112, Illinois State Water Survey, Urbana, Illinois, 29 p.

Notes:

- \* State of Illinois well numbering system is based on the location of the well, and uses township, range and section for identification as specified in the source information publications.

N/A indicates data were not available in source information.

**TABLE 2**  
**GROUND WATER MONITOR WELL DATA**  
**NL INDUSTRIES**  
**GRANITE CITY, ILLINOIS**  
**PREVIOUS DATA**

<u>Well Number</u>	<u>Elevation of Top of Steel Casing</u>	<u>Elevation of Top of PVC Casing</u>	<u>Elevation of Ground Level</u>	<u>Screened Interval</u>	<u>Elevation of Water Table 11/16/82</u>	<u>Elevation of Water Table 1/26/83</u>	<u>Elevation of Water Table 2/28/83</u>	<u>Elevation of Water Table 6/29/83</u>	<u>Elevation of Water Table 8/01/83</u>	<u>Elevation of Water Table 8/24/83</u>	<u>Elevation of Water Table 10/11/83</u>
101	421.9 ft.	421.52 ft.	418.9 ft.	407.0 - 397.0 ft.	399.3 ft.	402.8 ft.	402.9 ft.	404.2 ft.	-	402.7 ft.	401.90 ft.
102	417.3 ft.	416.88 ft.	414.0 ft.	402.0 - 392.0 ft.	399.2 ft.	401.7 ft.	401.6 ft.	404.2 ft.	-	399.7 ft.	398.7 ft.
103	417.6 ft.	417.26 ft.	414.6 ft.	403.0 - 393.0 ft.	398.8 ft.	402.1 ft.	401.9 ft.	402.7 ft.	-	400.4 ft.	399.2 ft.
104	420.8 ft.	420.25 ft.	417.8 ft.	406.0 - 396.0 ft.	397.7 ft.	400.5 ft.	400.6 ft.	401.7 ft.	-	400.1 ft.	399.0 ft.
105-S	N/A	428.87 ft.	425.9 ft.	405.0 - 400.0 ft.	-	-	-	-	402.07 ft.	401.29 ft.	399.97 ft.
105-D	N/A	428.99 ft.	426.2 ft.	396.0 - 391.0 ft.	-	-	-	-	402.09 ft.	401.30 ft.	399.89 ft.
106-S	N/A	424.00 ft.	421.1 ft.	406.0 - 401.0 ft.	-	-	-	-	402.00 ft.	Dry	Dry
106-D	N/A	423.93 ft.	421.8 ft.	392.0 - 387.0 ft.	-	-	-	-	402.03 ft.	401.15 ft.	399.83 ft.
107-S	N/A	421.07 ft.	419.0 ft.	402.0 - 397.0 ft.	-	-	-	-	404.77 ft.	404.58 ft.	403.27 ft.
107-D	N/A	421.97 ft.	419.0 ft.	389.0 - 384.0 ft.	-	-	-	-	402.97 ft.	400.99 ft.	399.67 ft.
108-S	N/A	422.88 ft.	419.9 ft.	405.0 - 400.0 ft.	-	-	-	-	402.08 ft.	401.10 ft.	399.98 ft.
108-D	N/A	421.88 ft.	420.0 ft.	390.0 - 385.0 ft.	-	-	-	-	401.58 ft.	400.63 ft.	399.28 ft.
109	415.9 ft.	415.75 ft.	416.3 ft.	387.3 - 382.3	-	-	-	-	-	-	-
110	418.8 ft.	418.64 ft.	419.2 ft.	389.2 - 384.2	-	-	-	-	-	-	-

**NOTES:** D denotes deep well  
S denotes shallow well  
Previous water table and casing elevation data provided by the USEPA with the exception of well number 109 and 110 installed by O'Brien & Gere Engineers 7/87.

TABLE 2 (Cont'd)

GROUND WATER MONITOR WELL DATA  
ML INDUSTRIES  
GRANITE CITY, ILLINOIS  
REMEDIAL INVESTIGATION DATA

Well Number	Elevation of Top of Steel Casing	Elevation of Top of PVC Casing	Elevation of Ground Level	Screened Interval	Elevation of Water Table 1/6/87	Elevation of Water Table 3/13/87	Elevation of Water Table 4/8/87	Elevation of Water Table 5/28/87	Elevation of Water Table 9/11/87	Elevation of Water Table 10/13/87	Elevation of Water Table 11/12/87
101	421.9 ft.	421.49 ft.*	418.9 ft.	407.0 - 397.0 ft.	401.86 ft.	401.32 ft.	401.15 ft.	401.02 ft.	400.52 ft.	400.42 ft.	400.22 ft.
102	417.3 ft.	416.88 ft.*	414.0 ft.	402.0 - 392.0 ft.	399.83 ft.	398.76 ft.	398.55 ft.	398.38 ft.	395.78 ft.	398.03 ft.	398.56 ft.
103	417.8 ft.	417.46 ft.*	414.6 ft.	403.0 - 393.0 ft.	401.16 ft.	399.30 ft.	399.13 ft.	398.96 ft.	398.46 ft.	398.30 ft.	398.65 ft.
104	420.8 ft.	420.25 ft.	417.8 ft.	406.0 - 396.0 ft.	398.97 ft.	398.13 ft.	397.92 ft.	397.84 ft.	397.45 ft.	397.12 ft.	397.20 ft.
105-S	N/A	428.87 ft.	425.9 ft.	405.0 - 400.0 ft.	401.27 ft.	DRY	DRY	DRY	DRY	DRY	DRY
105-D	N/A	428.99 ft.	426.2 ft.	396.0 - 391.0 ft.	401.24 ft.	394.99 ft.	399.74 ft.	399.58 ft.	399.89 ft.	398.93 ft.	399.47 ft.
106-S	N/A	424.00 ft.	421.1 ft.	406.0 - 401.0 ft.	401.04 ft.	DRY	DRY	DRY	DRY	DRY	DRY
106-D	N/A	423.93 ft.	421.8 ft.	392.0 - 387.0 ft.	401.16 ft.	399.93 ft.	399.64 ft.	399.48 ft.	398.93 ft.	398.83 ft.	399.01 ft.
107-S	N/A	421.07 ft.	419.0 ft.	402.0 - 397.0 ft.	403.34 ft.	402.93 ft.	402.07 ft.	402.16 ft.	403.57 ft.	401.73 ft.	401.59 ft.
107-D	N/A	421.97 ft.	419.0 ft.	389.0 - 384.0 ft.	400.94 ft.	398.91 ft.	399.60 ft.	399.39 ft.	398.07 ft.	398.86 ft.	399.02 ft.
108-S	N/A	422.88 ft.	419.9 ft.	405.0 - 400.0 ft.	400.72 ft.	DRY	DRY	DRY	DRY	DRY	DRY
108-D	N/A	421.88 ft.	420.0 ft.	390.0 - 385.0 ft.	400.58 ft.	399.51 ft.	399.22 ft.	398.97 ft.	398.58 ft.	398.54 ft.	398.83 ft.
109	415.9 ft.	415.75 ft.	416.3 ft.	387.3 - 382.3	-	-	-	-	398.65 ft.	398.54 ft.	398.75 ft.
110	418.9 ft.	418.64 ft.	419.2 ft.	389.2 - 384.2	-	-	-	-	399.94 ft.	399.71 ft.	398.03 ft.

NOTES: D denotes deep well  
S denotes shallow well  
Remedial investigation water table elevation data provided by O'Brien & Gere Engineers  
\* Resurveyed 8/87. RI values based on most recent survey

**TABLE 3**  
**DESCRIPTION OF WASTE PILE EXCAVATION 1**

<u>Depth(ft)</u>	<u>Description</u>
0-1	Plastic battery casing, hard rubber battery casing, fine-grained material
1-6	Slag pieces up to 500 lb., fine-grained material
6-7	Slag pieces up to 1 lb., hard rubber battery casing, fine-grained material
7-10	Slag pieces up to 500 lb., fine-grained material
10-12	Slag pieces up to 1 lb., fine-grained material
12-18	Slag pieces up to 500 lb., refractory bricks, crushed slag, fine-grained material
18-19	Light gray clay-like material
19-20	Grayish brown clay-like material, sand

**Notes:**

**Waste pile excavation conducted on April 9, 1987.**

TABLE 4

DESCRIPTION OF WASTE PILE EXCAVATION 2

<u>Depth(ft)</u>	<u>Description</u>
0-1	Slag pieces up to 10 lb., plastic battery casing, fine-grained material
1-8	Hard rubber battery casing, plastic battery casing, fine-grained material
8-9	Slag pieces up to 5 lb., hard rubber battery casing, plastic battery casing, fine-grained material
9-15	Hard rubber battery casing, fine-grained material
15-16	Slag pieces up to 5 lb., hard rubber battery casing, fine-grained material
16-22	Hard rubber battery casing, crushed slag, fine-ground material
22-24	Dark gray/black clay-like material

Notes:

Waste pile excavation conducted on April 9, 1987.

TABLE 5<sup>\*</sup>  
 REMEDIAL INVESTIGATION  
 ANALYTICAL PROGRAM  
 JUNE 1986 REVISION

Sample Site	#	Field Sieve	Lab <sub>2</sub> Sieve	Digest	Ext.	Filt.	pH	Cond.	Pb	Cd	Cr	Ba	As	Hg	Se	Ag	Sb	Cu	Fe	Mn	Ni	Zn	SO <sub>4</sub>	TDS
3a																								
Slag	4	--	4	4	2	--	--	--	6	6	6	6	6	6	6	6	4	4	4	4	4	4	--	--
Upper Strata	10	10	--	10	5	--	--	--	15	15	15	15	15	15	15	15	10	10	10	10	10	10	--	--
SILR Pile	2	2	--	2	1	--	--	--	3	3	3	3	3	3	3	3	2	2	2	2	2	2	--	--
Drummed Material	2	--	--	0	1	--	*	*	3	3	3	3	3	3	3	3	2	2	2	2	2	2	--	--
3b																								
Wells Quarter - 1	15	--	--	3	--	12	15	15	15	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Wells Quarter - 2	15	--	--	3	--	12	15	15	15	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
3c																								
Soils Grid	72	--	72	72	--	--	--	--	72	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Off-Site Removal Areas	11	--	11	11	--	--	--	--	11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3d																								
Deposition	4	--	--	4	--	--	--	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Runoff	4	--	--	4	--	--	4	4	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Notes:

- <sup>1</sup> Field sieving indicates that samples will be sieved in the field through a 9.5 mm standard sieve. That portion passing through the sieve will be collected and submitted for analysis.
- <sup>2</sup> Lab sieving indicates that soil samples will be sieved through a 16 mesh stainless steel sieve after drying (8 hours at 100°C, or until dry), prior to analysis. Slag samples will be crushed and sieved through a 9.5 mm standard sieve in the laboratory prior to analysis.

\* If the drummed materials are solid wastes, they will undergo digestion. If they are liquid wastes, they will be tested for pH and conductivity in the field.

\*\* Second quarter groundwater samples will be analyzed for those parameters observed in significant concentrations in the first quarter groundwater analysis, as jointly agreed upon by USEPA, IEPA, and M. Industries.

The analytical program is to include one EPA Toxicity (Metals only) for Off-Site soils with highest Pb if over 1000 ppm.

In the event that activities in Task 1 determine that environmentally significant parameters are present, these parameters will be included in 3a and/or 3b1 above, for utilization where parameter involvement is suspected.

The preceding narrative is modified by reference to be consistent with this table. In the event of a discrepancy between this table and the RIMP, this table will be governing.

<sup>\*</sup> This table excerpted from O'Brien & Gere, 1986.

TABLE 5 (Cont'd)\*\*  
 REMEDIAL INVESTIGATION  
 SUPPLEMENTAL STUDIES  
 ANALYTICAL PROGRAM

Sample Site	Sample (Dates)	Elev (Dates)	Digest	Filt.	pH	Cond	TDS	SO <sub>4</sub>	Pb	Cd	Cr	Be	As	Hg	Se	Ag	Sb	Cu	Fe	Mn	Ni	Zn
NW-101	2	4	--	2	2	2	2	2	2	2	--	--	2	--	--	--	--	--	2	2	2	2
NW-102	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NW-103	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NW-104	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NW-1055	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NW-105D	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NW-1065	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NW-106D	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NW-1075	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NW-107D	2	4	2	3	3	3	3	3	5	3	--	--	3	--	--	--	--	--	3	3	3	3
NW-1085	2	4	--	2	2	2	2	2	2	2	--	--	2	--	--	--	--	--	2	2	2	2
NW-108D	2	4	2	2	2	2	2	2	4	2	--	--	2	--	--	--	--	--	2	2	2	2
NW-109	2	4	3	3	3	3	3	3	6	3	3	3	3	3	3	3	3	3	3	3	3	3
NW-110	2	4	3	2	2	2	2	2	5	2	2	2	2	2	2	2	2	2	2	2	2	2

\*\* This table excerpted from O'Brien & Gere, 1987.

**TABLE 6**  
**ESTIMATED ATMOSPHERIC LEAD EMISSIONS FOR THE**  
**UNITED STATES, 1981, AND THE WORLD, 1979<sup>(1)</sup>**

<u>Source Category</u>	<u>Annual (1981) U.S. Emissions<sup>(2)</sup> (tons/yr)</u>	<u>Percentage of U.S. Total Emissions</u>	<u>Annual (1979) Global Emissions<sup>(3)</sup> (tons/year)</u>
Gasoline Combustion	61,000	91.4%	273,000
Waste Oil Combustion	830	1.2	8,900
Solid Waste Disposal	319	0.5	
Coal Combustion	950	1.4	15,000
Oil Combustion	226	0.3	6,000
Wood Combustion	--	--	4,500
Gray Iron Production	295	0.5	50,000
Iron and Steel Production	533	0.8	
Secondary Lead Smelting	631	0.9	770
Primary Copper Smelting	30	0.1	27,000
Ore Crushing and Grinding	326	0.5	8,200
Primary Lead Smelting	921	1.4	31,000
Other Metallurgical	54	0.1	
Zn Smelting			16,000
Ni Smelting			2,500
Lead Alkyl Manufacture	245	0.4	
Type Metal	85	0.1	7,400
Portland Cement Production	71	0.1	
Miscellaneous	233	0.3	5,900
Total	66,749 <sup>(4)</sup>	100%	449,170

(1) Adapted from: USEPA, 1984. Air Quality Criteria for Lead. EPA-600/8-83-028B. USEPA, Environmental Criteria and Assessment Office, Research Triangle Park, N.C.

(2) Source: Battye, B., 1983. "Lead Emissions Inventory, 1981." Memo to John Haines, January 31, 1983. USEPA, Environmental Criteria and Assessment Office, Research Triangle Park, N.C.

(3) Source: Nriagu, J.O., 1979. "Global Inventory of Natural and Anthropogenic Emissions of Trace Metals to the Atmosphere." Nature. London. 279:409-411.

(4) Inventory does not include emissions from exhausting workroom air, burning of lead-painted surfaces, welding of lead-painted steel structures, or weathering of painted surfaces.

TABLE 7

AMBIENT AIR LEAD MONITORING DATA - QUARTERLY AVERAGES ( $\mu\text{g}/\text{m}^3$ )<sup>(1)</sup>

<u>Year/Quarter</u>	<u>IEPA Air Monitor Location</u>				
	<u>15th &amp; Madison</u>	<u>19th &amp; Adams</u>	<u>Roosevelt &amp; Rock Road</u>	<u>1735 Cleveland</u>	<u>2001 &amp; 20th</u>
1978 - 2	3.1	0.6	0.7	--	--
3	1.7	4.4	1.3	--	--
4	4.4	4.0	1.3	--	--
1979 - 1	2.6	1.0	1.3	--	--
2	3.2	0.9	1.2	--	--
3	2.0	1.1	1.3	--	--
4	3.0	2.6	1.2	--	--
1980 - 1	3.0	0.5	0.6	--	--
2	1.2	0.6	0.5	--	--
3	1.0	0.5	0.7	--	--
4	1.9	0.6	1.4	--	--
1981 - 1	2.1	0.5	0.5	--	--
2	1.0	1.6	0.9	--	--
3	1.8	0.5	1.1	--	--
4	7.3	0.5	0.9	--	--
1982 - 1	1.9	0.8	1.1	--	--
2	1.6	0.9	1.5	--	--
3	1.1	0.5	0.6	--	--
4	0.9	0.6	1.8	1.5	--
1983 - 1	1.1	0.5	0.4	1.0	--
2	0.4	0.3	0.3	0.7	--
3	0.68	0.37	0.36	0.76	--
4	0.76	0.51	0.67	0.62	--
1984 - 1	1.48	0.31	0.37	0.74	--
2	0.76	0.29	0.30	0.74	--
3	0.34	0.23	0.23	0.40	--
4	0.39	0.26	0.30	0.45	--
1985 - 1	0.59	0.13	0.14	0.25	0.23
2	0.42	0.26	0.20	0.44	0.28
3	0.23	0.17	0.21	0.33	0.20
4	0.27	0.18	0.17	0.28	0.20
1986 - 1	0.44	0.15	(2)	0.42	0.23
2	0.24	0.13	(2)	0.28	0.15
3	0.24	0.15	(2)	0.38	0.15
4	0.32	0.20	(2)	0.24	0.23

Notes:

- (1) Data from Illinois Environmental Protection Agency
- (2) Monitor discontinued

TABLE 8

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

<u>Matrix</u>	<u>ARAR</u>
Waste Piles	<ul style="list-style-type: none"><li>- 40 CFR Part 260 - Hazardous Waste Management System: General;</li><li>- 40 CFR Part 261 - Identification and Listing of Hazardous Waste;</li><li>- 40 CFR Part 262 - Standards Applicable to Generators of Hazardous Waste;</li><li>- 40 CFR Part 263 - Standards Applicable to Transporters of Hazardous Waste;</li><li>- 40 CFR Part 264 - Standards for Owners and Operators of Hazardous; Waste Treatment, Storage, and Disposal Facilities;</li><li>- 40 CFR Part 265 - Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities;</li><li>- 40 CFR Part 266 - Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities;</li><li>- 40 CFR Part 267 - Interim Standards for Owners and Operators of New Hazardous Waste Land Disposal Facilities;</li><li>- 40 CFR Part 268 - Land Disposal Restrictions;</li><li>- 35 Illinois Administrative Code, Part 700 - Outline of Waste Disposal Regulations;</li><li>- 35 Illinois Administrative Code, Part 702 - RCRA and UIC Permit Programs;</li><li>- 35 Illinois Administrative Code, Part 703 - RCRA Permit Program;</li><li>- 35 Illinois Administrative Code, Part 720 - Hazardous Waste Management System: General;</li><li>- 35 Illinois Administrative Code, Part 721 - Identification and Listing of Hazardous Waste;</li><li>- 35 Illinois Administrative Code, Part 722 - Standards Applicable to Generators of Hazardous Waste;</li><li>- 35 Illinois Administrative Code, 723 - Standards Applicable to Transporters of Hazardous Waste;</li><li>- 35 Illinois Administrative Code, Part 724 - Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities;</li><li>- 35 Illinois Administrative Code, Part 725 - Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities;</li><li>- 35 Illinois Administrative Code, Part 726 - Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities; and</li><li>- 35 Illinois Administrative Code, Part 729 - Landfills: Prohibited Hazardous Wastes.</li></ul>
Ground Water	<ul style="list-style-type: none"><li>- 35 Illinois Administrative Code, Part 302 - Water Quality Standards, Subpart A - General Water Quality Provisions</li></ul>

TABLE 8

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS  
(Continued)

<u>Matrix</u>	<u>ARAR</u>
Ground Water	<ul style="list-style-type: none"><li>- 35 Illinois Administrative Code, Part 302 - Water Quality Standards, Subpart B - General Use Water Quality Standards</li><li>- 35 Illinois Administrative Code, Part 303 - Water Use Designations and Site Specific Water Quality Standards, Subpart A - General Provisions; and</li><li>- 35 Illinois Administrative Code, Part 303 - Water Use Designations and Site Specific Water Quality Standards, Subpart B - Nonspecific Water Use Designations.</li></ul>
Air	<ul style="list-style-type: none"><li>- 40 CFR Part 50 - National Primary and Secondary Ambient Air Quality Standards;</li><li>- 35 Illinois Administrative Code, Part 211 - Illinois Emission Standards and Limitations for Stationary Sources, Definitions and General Provisions;</li><li>- 35 Illinois Administrative Code, Part 212 - Illinois Emission Standards and Limitations for Stationary Sources, Visual and Particulate Matter Emissions; and</li><li>- 35 Illinois Administrative Code, Part 234 - Illinois Air Quality Standards.</li></ul>

**TABLE 9**  
**GROUND WATER QUALITY STANDARDS**

<u>Parameter</u>	<u>General Use (1) (mg/l)</u>
Arsenic	1.0
Barium	5.0
Boron	1.0
Cadmium	0.05
Chloride	500
Chromium VI	0.05
Chromium CR III	1.0
Copper	0.02
Cyanide	0.025
Fluoride	1.4
Iron	1.0
Lead	0.1
Manganese	1.0
Mercury	0.0005
Nickel	1.0
Phenols	0.1
Selenium	1.0
Silver	0.005
Sulfate	500.
TDS	1000.
Zinc	1.0

(1) 35 Illinois Administrative Code Part 302, Subpart B defines these standards for ground water in Illinois.

**TABLE 10**

**REMEDIAL RESPONSE OBJECTIVES**

<u>Exposure Pathway</u>	<u>Objective</u>	<u>Criteria</u>
Soil	- Achieve an acceptable level of risk from direct contact with contaminated soils, fill, and paving materials.	- Surface soil lead concentration that will not pose risks to human health as determined by the site-specific risk assessment.
Waste Pile	- Achieve an acceptable level of risk from inhalation or direct contact with the waste piles containing wastes from secondary lead smelting process.	- Surface lead concentration that will not pose risks to human health as determined by the site-specific risk assessment.
Air	- Maintain lead concentrations in air at concentrations which do not pose risks to human health as defined in 40 CFR Part 50.	- Ambient air lead concentration of 1.5 ug/m <sup>3</sup> .
Ground Water	- Meet Illinois General Use Water Standards 35 IAC Part 302B.	- Reduce Fe, Mn, Zn, Cd, TDS, SO <sub>4</sub> to IEPA ground water quality standards (35 IAC Part 302B) at hydraulically downgradient wells 109, 104, 107, 106.

TABLE 11  
PRELIMINARY REMEDIAL TECHNOLOGIES

<u>General Response Action</u>	<u>Preliminary Remedial Technology</u>
No Action	Monitoring
Containment	Capping Barrier wall
Pumping	Ground water pumping
Collection	Subsurface drains
Diversion	Grading
Complete Removal	Excavation of contaminated waste material and/or soil Drums
Partial Removal	Excavation of contaminated waste material and/or soil Drums
On-Site Treatment	Recycle/recovery Solidification Stabilization/Fixation Chemical and physical treatment Incineration
Off-Site Treatment	Recycle/recovery Solidification Stabilization/Fixation Chemical and physical treatment Incineration
In-Situ Treatment	Stabilization/fixation
Storage	Temporary storage structures
On-Site Disposal	Landfills
Off-Site Disposal	Landfills

TABLE 12  
NL INDUSTRIES  
GRANITE CITY  
GROUND WATER DATA SUMMARY

parameter	SHALLOW WELLS <sup>(2)</sup>															
	101		102		103		104		105		106		107		108	
	avg.	max.	avg.	max.	avg.	max.	avg.	max.	avg.	max.	avg.	max.	avg.	max.	avg.	max.
Sulfate	168	190	165	210	190	210	125	130	-	320	-	290	280	300	-	1250
Total Dissolved Solids	615	690	625	640	525	550	380	400	-	1000	-	1100	835	850	-	3110
Lead <sup>(1)</sup>	.004*	.009	.008*	.012	LT.005	LT.005	LT.005	LT.005	-	LT.005	LT.005	LT.005	LT.005	LT.005	-	.005
Barium <sup>(1)</sup>	LT 1	LT 1	LT 1	LT 1	LT 1	LT 1	LT 1	LT 1	-	LT 1	-	LT 1	LT 1	LT 1	-	LT 1
Cadmium <sup>(1)</sup>	.002*	.007	LT.001	LT.001	.001*	.002	.001*	.002	-	.002	-	.013	.001*	.001	-	.209
Selenium <sup>(1)</sup>	LT.0035	LT.005	LT.0035	LT.005	.003*	.003	.003*	.003	-	LT.005	-	LT.005	LT.0035	LT.005	-	LT.005
Arsenic <sup>(1)</sup>	.079	.101	LT.005	LT.005	LT.005	LT.005	LT.005	LT.005	-	LT.005	-	LT.005	LT.005	LT.005	-	LT.005
Copper <sup>(1)</sup>	LT.01	LT.01	LT.01	LT.01	LT.01	LT.01	LT.01	LT.01	-	LT.01	-	LT.01	LT.01	LT.01	-	LT.01
Iron <sup>(1)</sup>	21	22	.085*	.12	LT.1	LT.1	LT.1	LT.1	-	LT.1	-	LT.1	LT.1	LT.1	-	LT.1
Nickel <sup>(1)</sup>	LT.01	LT.01	LT.01	LT.01	LT.01	LT.01	LT.01	LT.01	-	LT.01	-	LT.01	LT.01	LT.01	-	LT.01
Manganese <sup>(1)</sup>	4.7	5.5	.197	.27	.036*	.06	.028	.03	-	LT.025	-	.08	.105	.139	-	13.1
Silver <sup>(1)</sup>	LT.005	LT.005	LT.005	LT.005	LT.005	LT.005	LT.005	LT.005	-	LT.005	-	LT.005	LT.005	LT.005	-	LT.005
Zinc <sup>(1)</sup>	.039*	.10	LT.035	LT.05	LT.035	LT.05	LT.035	LT.05	-	LT.02	-	.27	LT.035	LT.05	-	.04
Chromium <sup>(1)</sup>	LT.005	LT.005	LT.005	LT.005	LT.005	LT.005	LT.005	LT.005	-	LT.005	-	LT.005	LT.005	LT.005	-	LT.005
Antimony <sup>(1)</sup>	LT.02	LT.02	LT.02	LT.02	LT.02	LT.02	LT.02	LT.02	-	LT.02	-	LT.02	LT.02	LT.02	-	LT.02
Mercury <sup>(1)</sup>	LT.0005	LT.0005	LT.0005	LT.0005	LT.0005	LT.0005	LT.0005	LT.0005	-	LT.0005	-	LT.0005	LT.0005	LT.0005	-	LT.0005

(1) Filterable Values

(2) All data reported in units of mg/l

\* Average values calculated using one-half of detection limit for less than detectable values.

TABLE 13  
ML INDUSTRIES  
GRANITE CITY  
GROUND WATER DATA SUMMARY

DEEP WELLS <sup>(2)</sup>

parameter	105		106		107		108		109		110	
	avg.	max.	avg.	max.	avg.	max.	avg.	max.	avg.	max.	avg.	max.
Sulfate	160	180	210	260	507	550	1759	1825	74	78	288	294
Total Dissolved Solids	640	660	685	770	1290	1370	4315	4600	520	530	993	1000
Lead <sup>(1)</sup>	LT.005	LT.005	.012	.013	LT.005	LT.005	.007*	.009	LT.005	LT.005	LT.005	LT.005
Barium <sup>(1)</sup>	LT 1	LT 1	LT 1	LT 1	LT 1	LT 1	LT 1	LT 1	LT 1	LT 1	LT 1	LT 1
Cadmium <sup>(1)</sup>	.003*	.006	.005	.008	LT.001	LT.001	3.85*	6.9	LT.001	LT.001	.002*	.004
Selenium <sup>(1)</sup>	LT.035	LT.005	.0028*	.003	LT.0035	LT.005	LT.0035	LT.005	LT.002	LT.002	LT.002	LT.002
Arsenic <sup>(1)</sup>	-	LT.005	.0037*	.005	.0068*	.014	.006*	.007	.0037*	.006	LT.005	LT.005
Copper <sup>(1)</sup>	LT.01	LT.01	.0125*	.02	LT.01	LT.01	LT.01	LT.01	LT.01	LT.01	LT.01	LT.01
Iron <sup>(1)</sup>	-	LT .1	LT .1	LT .1	6.7	8.1	LT .1	LT .1	.17*	.4	LT .1	LT .1
Nickel <sup>(1)</sup>	LT.01	LT.01	LT.01	LT.01	LT.01	LT.01	.74	.94	LT.01	LT.01	.013	.02
Manganese <sup>(1)</sup>	.237	.284	.184	.359	.40	.43	25.4	29.4	.163	.28	.99	1.0
Silver <sup>(1)</sup>	LT.005	LT.005	LT.005	LT.005	LT.005	LT.005	LT.005	LT.005	LT.005	LT.005	LT.002	LT.005
Zinc <sup>(1)</sup>	.0275*	.03	.067	.09	LT.02	LT.05	42.3	44	LT.02	LT.02	.013*	.02
Chromium <sup>(1)</sup>	LT.005	LT.005	LT.005	LT.005	LT.005	LT.005	LT.005	LT.005	LT.005	LT.005	LT.005	LT.005
Antimony <sup>(1)</sup>	LT.02	LT.02	LT.02	LT.02	LT.02	LT.02	LT.02	LT.02	LT.02	LT.02	LT.02	LT.02
Mercury <sup>(1)</sup>	LT.0005	LT.0005	LT.0005	LT.0005	LT.0005	LT.0005	LT.0005	LT.0005	LT.0002	LT.0002	LT.0002	LT.0002

(1) Filterable Values

(2) All data reported in units of mg/l

\* Average values calculated using one-half of detection limit for less than detectable values.

TABLE 14

NL INDUSTRIES GRANITE CITY  
GROUND WATER MONITORING WELL CHARACTERISTICS

Monitoring Well		(10-Jan-87)	(06-Apr-87)	(12-Aug-87)	(12-Nov-87)	Average	Std. Dev.
101	LWC (ft.)	6.54	6.10	5.83	5.13	5.90	0.59
	Gallons	1.00	0.99	0.95	0.85	0.95	0.07
	Ave. pH	6.8	6.6	6.6	6.7	6.7	0.1
	Ave. SPCOND (umhos/cm)	690	770	825	970	814	118
102	LWC (ft.)	8.45	7.05			7.75	0.99
	Gallons	1.30	1.15			1.23	0.11
	Ave. pH	6.6	6.1			6.4	0.4
	Ave. SPCOND (umhos/cm)	800	815			808	11
		(17-Jan-87)					
103	LWC (ft.)	6.00	5.40			5.70	0.42
	Gallons	1.00	0.90			0.95	0.07
	Ave. pH	6.5	6.6			6.6	0.1
	Ave. SPCOND (umhos/cm)	900	680			790	156
104	LWC (ft.)	7.60	6.45			7.03	0.81
	Gallons	1.20	1.05			1.13	0.11
	Ave. pH	5.7	5.6			5.7	0.1
	Ave. SPCOND (umhos/cm)	345	470			408	88
105S	LWC (ft.)	1.20					
	Gallons	0.19					
	Ave. pH	6.6					
	Ave. SPCOND (umhos/cm)	680					
105D	LWC (ft.)	9.88	8.50			9.19	0.98
	Gallons	1.60	1.39			1.50	0.15
	Ave. pH	6.6	6.1			6.4	0.4
	Ave. SPCOND (umhos/cm)	680	760			720	57
106S	LWC (ft.)	1.20	Dry				
	Gallons	0.07					
	Ave. pH						
	Ave. SPCOND (umhos/cm)						
106D	LWC (ft.)	14.73	13.35			14.04	0.98
	Gallons	2.40	2.18			2.29	0.16
	Ave. pH	6.8	6.2			6.5	0.4
	Ave. SPCOND (umhos/cm)	640	920			780	198

TABLE 14

NL INDUSTRIES GRANITE CITY  
GROUND WATER MONITORING WELL CHARACTERISTICS  
(Continued)

Monitoring Well		(10-Jan-87)	(06-Apr-87)	(12-Aug-87)	(12-Nov-87)	Average	S.Dev.
107S	LWC (ft.)	6.57	5.20			5.89	0.97
	Gallons	1.07	0.85			0.96	0.16
	Ave. pH	6.8	6.8			6.8	0.0
	Ave. SPCOND	815	980			898	117
	(umhos/cm)						
107D	LWC (ft.)	17.70	14.66	13.80	14.55	15.18	2.11
	Gallons	2.80	2.40	2.25	2.41	2.47	0.29
	Ave. pH	6.7	6.6	6.8	6.8	6.7	0.1
	Ave. SPCOND	1377	1400	1400	1300	1369	58
	(umhos/cm)						
108S	LWC (ft.)	1.06	Dry	Dry	Dry		
	Gallons	0.17					
	Ave. pH	6.1					
	Ave. SPCOND	2300					
	(umhos/cm)						
108D	LWC (ft.)	11.98	10.20	9.96	9.57	10.43	1.07
	Gallons	1.95	1.70	1.60	1.60	1.71	0.17
	Ave. pH	6.4	5.7	5.9	6.0	6.0	0.3
	Ave. SPCOND	3300	4310	3930	4300	3960	474
	(umhos/cm)						
109	LWC (ft.)			16.06	15.49	15.78	0.40
	Gallons			2.62	2.57	2.60	0.04
	Ave. pH			6.7	6.8	6.8	0.1
	Ave. SPCOND			700	620	660	57
	(umhos/cm)						
110	LWC (ft.)			12.75	13.12	12.94	0.26
	Gallons			2.08	2.18	2.13	0.07
	Ave. pH			6.6	6.8	6.7	0.1
	Ave. SPCOND			1100	1100	1100	0
	(umhos/cm)						

**Notes:**

LWC = Distance from top of water table to bottom of well casing.

Gallons = Volume of ground water in well prior to sampling. A minimum of three well volumes were evacuated prior to sampling.

\* = Less than three well volumes available in monitoring well.

pH = pH of ground water in standard units - mean of four measurements.

SPCOND = Conductivity of ground water in micromhos/cm-mean of four measurements.

(1) = Insufficient volume available in monitoring well.

TABLE 15

TARACORP SITE  
SOIL SAMPLES LAB ANALYSES

## Boring - 105

SAMPLE INTERVAL	ARSENIC	ANTIMONY	LEAD	ZINC	MAGNESIUM
2.5'-4.0'	10	4	520	92	2,700
5.5'-7.0'	6.4	1	96	50	1,900
8.5'-10.0'	7.1	1	60	53	5,500
11.5'-13.0'	4.6	1	13	39	5,500
14.5'-16.0'	2.6	1	9	30	4,000
17.5'-19.0'	2.5	1	11	29	3,600
20.5'-22.0'	1.7	1	18	22	1,600
23.5'-25.0'	2.8	1	10	29	2,300

## Boring - 106

SAMPLE INTERVAL	ARSENIC	ANTIMONY	LEAD	ZINC	MAGNESIUM
0.0'-5.0'	6.1	13	290	2,200	1,200
7.5'-10.00'	8	1	27	120	6,500
11.5'-13.0'	5.6	1	22	120	6,000
14.5'-16.0'	11	2	510	100	7,000
17.5'-19.0'	2.5	1	14	38	5,000
20.0'-22.0'	2.1	1	67	29	2,600
24.5'-27.0'	1.5	1	8	23	1,500
30.0'-33.0'	1.3	1	7	20	1,300

## Boring - 107

SAMPLE INTERVAL	ARSENIC	ANTIMONY	LEAD	ZINC	MAGNESIUM
3.5'-5.0'	150	20	15	580	1,700
7.2'-8.7'	80	20	25	65	6,000
11.5'-13.0'	8.6	1	22	65	7,500
14.5'-16.0'	8.6	1	230	58	7,000
17.5'-19.0'	3.2	1	37	50	5,500
20.5'-22.0'	3.4	1	33	41	5,500
30.0'-33.8'	6	1	22	67	6,500

## Boring - 108

SAMPLE INTERVAL	ARSENIC	ANTIMONY	LEAD	ZINC	MAGNESIUM
2.5'-5.0'	40	5	150	27	7,500
5.0'-6.4'	30	2	70	37	1,300
6.4'-10.0'	8	1	15	74	1,400
10.0'-10.8	12	3	120	39	350
10.8'-11.5'	7.9	1	110	120	3,000
11.5'-13.0'	6.6	1	22	140	2,500
13.0'-14.5'	5.6	1	21	140	1,600
14.5'-16.0'	6.4	LT 1	15	100	1,400
16.0'-17.5'	6.1	LT 1	18	100	1,500
17.5'-19.0'	2.8	LT 1	11	29	1,100
19.0'-20.5'	2.7	LT 1	10	26	950
20.5'-22.0'	2.7	1	14	27	1,000
20.0'-25.0'	5.3	1	63	82	1,500
25.0'-27.5'	3.8	1	23	250	2,900
27.5'-30.0'	3.2	1	18	33	3,000
30.0'-32.5'	4.4	1	33	58	3,800
32.5'-35.0'	5.1	1	48	71	4,000

## Boring - 101

## SAMPLE INTERVAL LEAD

4'-5.5'	43
9'-10.5'	51
14'-15.5'	2,700
19'-20.5'	43
24'-25.5'	14
29'-30.5'	13

NOTE: Concentrations in ppm  
Sources: IEPA, 1983 (a)  
IEPA, 1984

LT indicates less than the reported value

TABLE 16

## SELECTED PHYSICAL PROPERTIES OF A FEW LEAD COMPOUNDS

<u>Element/ Compound</u>	<u>Formula</u>	<u>Atomic Molecular/ Weight</u>	<u>Water Solubility</u>	<u>Vapor Pressure</u>
Lead	Pb	207.19	insoluble	1mm at 973°C
Lead chloride	PbCl <sub>2</sub>	278.10	0.99 g/100 mL at 20°C	1 mm at 547°C
Lead bromide	PbBr <sub>2</sub>	367.01	0.844 g/100 mL at 20°C	1 mm at 513°C
Lead oxide	PbO	223.19	$1.7 \times 10^{-2}$ g/100 mL at 20°C	1 mm at 943°C
Lead sulfide	PbS	239.19	$8.6 \times 10^{-5}$ g/100 mL at 25°C	1 mm at 852°C
Lead sulfate	PbSO <sub>4</sub>	303.25	$4.25 \times 10^{-3}$ g/100 mL at 25°C	NA
Lead tetramethyl	Pb(CH <sub>3</sub> ) <sub>4</sub>	267.33	15 mg/L (Pb) <sup>a</sup>	22.5 mm at 20°C
Lead tetraethyl	Pb(C <sub>2</sub> H <sub>5</sub> ) <sub>4</sub>	323.44	0.8 mg/L at 20°C	0.15 mm at 20°C

<sup>a</sup> Temperature not available  
NA - Not available

TABLE 17  
 SUMMARY OF LOWEST BLOOD LEAD LEVELS  
 ASSOCIATED WITH OBSERVED PHYSIOLOGICAL EFFECTS  
 IN HUMANS

<u>Lowest Observed Effect Level (ug Pb/dl Blood)</u>	<u>Effect</u>	<u>Population Group</u>
10	aminolevulinic acid dehydrase inhibition (erythrocyte enzyme)	Children and adults
15-20	erythrocyte protoporphyrin elevation	women and children
15-20	central nervous system electrophysiological deficits	children
25-30	erythrocyte protoporphyrin elevation	adult males
40	increased urinary aminolevulinic acid excretion	children and adults
40	anemia	children
40	coproporphyrin elevation	adults and children
50	anemia	adults
50-60	cognitive central nervous system deficits	children
50-60	peripheral neuropathies	adults and children
80-100	encephalopathic symptoms	children
100-120	encephalopathic symptoms	adults

Adapted from U.S. EPA (1984)

TABLE 18

## INHALATION RISK ASSESSMENT

	Air Concentration ug/m <sup>3</sup> (1987 mean)	Exposure Rate ug/kg/day	Rfd <sup>2</sup> or AIC <sup>2</sup> ug/kg/day	Cancer Potency <sup>2</sup> (mg/kg/day) <sup>-1</sup>	Hazard <sup>3</sup> Index	Cancer Risk
Lead	0.26	0.074	0.43	N.A.	0.17	--
Arsenic	0.007	0.002	N.A.	1.5	--	$3 \times 10^{-6}$
Beryllium	0	--	--	--	--	--
Cadmium	0.009	0.0026	N.A.	6.1	--	$1.6 \times 10^{-5}$
Chromium	0.022	0.006	N.A.	41 (CrVI)	--	$2.6 \times 10^{-4}$

<sup>1</sup> Determined using 70 kg body weight, 20 m<sup>3</sup>/day breathing rate, 100% absorption rate and 1987 mean Granite City air concentration.

<sup>2</sup> Reference doses, Acceptable Daily Intakes, and Cancer Potency Factors Obtained from Superfund Public Health Evaluation Manual, ATSDR Toxicological Profiles, or IRIS, as available.

<sup>3</sup> Hazard Index = Exposure Rate/Rfd for chronic exposure to non-carcinogen.

**TABLE 19**  
**INGESTION RISK RANKING**

	<u>Soil Concentration</u> <u>mg/kg</u> <u>(mean)</u>	<u>Exposure<sup>1</sup></u> <u>Rate</u> <u>ug/kg/day</u>	<u>Rfd<sup>2</sup></u> <u>or AIC</u> <u>ug/kg/day</u>	<u>Hazard<sup>3</sup></u> <u>Index</u>
Lead	1970 <sup>4</sup>	2.81	0.97 <sup>5</sup>	2.90
Cadmium	3.7	0.005	0.29	0.017
Chromium	55.6	0.08	5 <sup>6</sup>	0.016
Zinc	450	0.65	200	0.003
Antimony	20.2	0.71	0.4	0.072

<sup>1</sup> Determined using 70 kg body weight, daily ingestion of 100 mg of soil (as suggested in Superfund Public Health Exposure Manual for initial ranking and selection of site contaminants), and mean soil residues, calculated from data in Section 5.

<sup>2</sup> Obtained from Superfund Public Health Evaluation Manual or IRIS.

<sup>3</sup> Hazard Index = Exposure Rate/Rfd.

<sup>4</sup> Mean value from data reported in the RI/FS.

<sup>5</sup> AIC revised downward from 1.4 mg/kg/day to reflect revised opinions of lead chronic effects.

<sup>6</sup> Rfd for Cr VI, the more chronically toxic form of Cr.

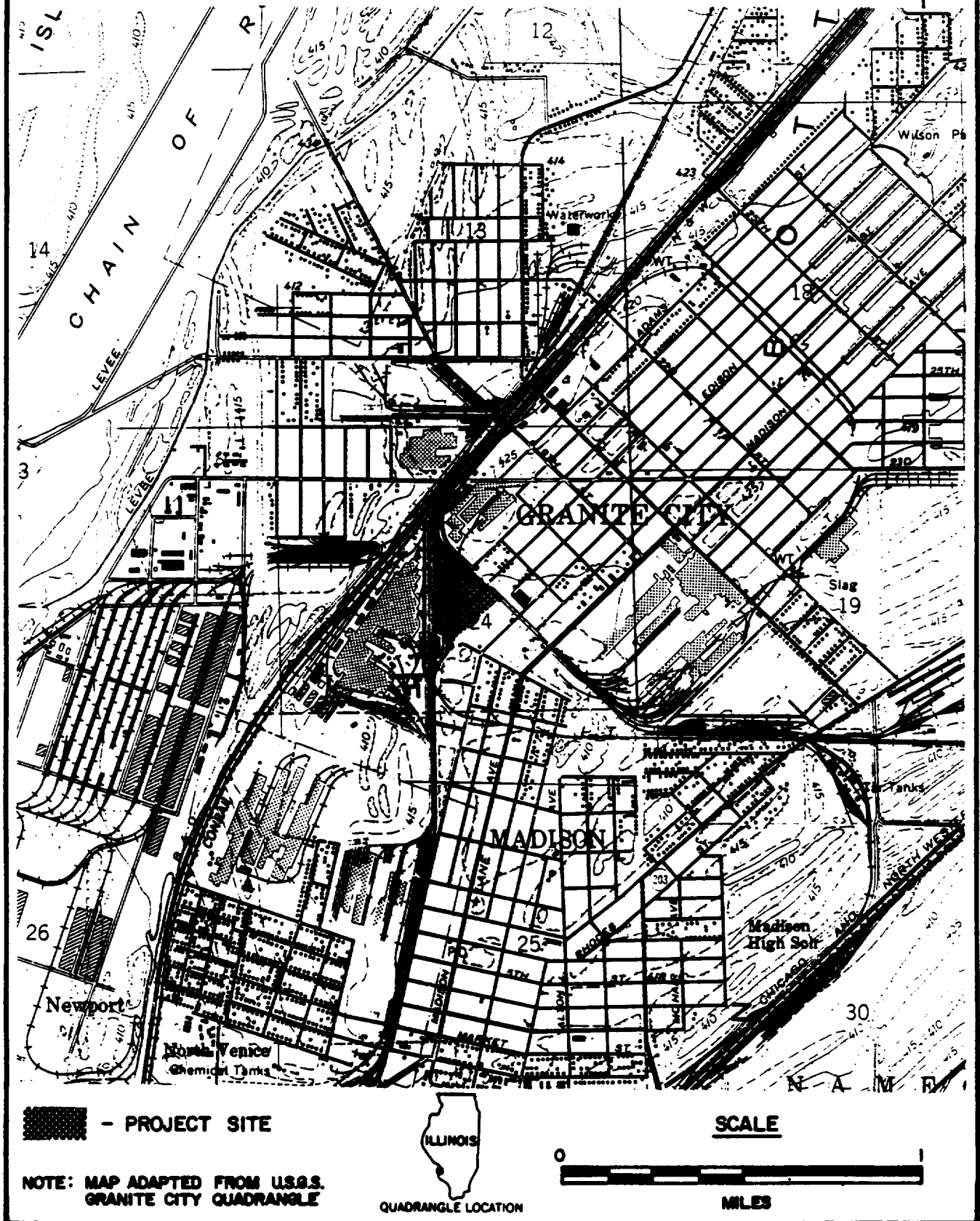
# Figures

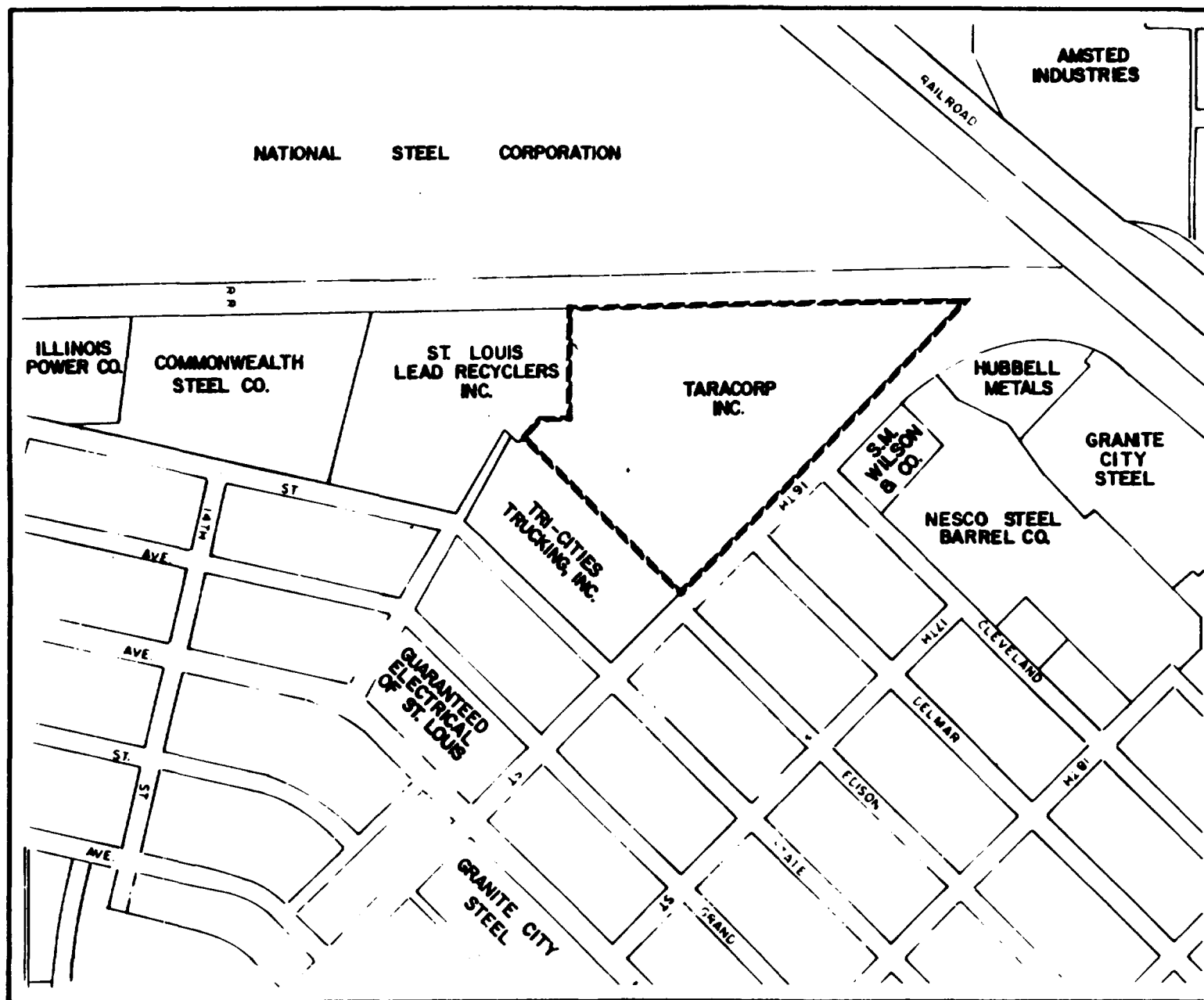
---

FIGURE 1

NL INDUSTRIES  
GRANITE CITY SITE  
GRANITE CITY, ILLINOIS

LOCATION MAP





NL INDUSTRIES  
GRANITE CITY SITE  
GRANITE CITY, ILLINOIS

ADJACENT  
PROPERTIES  
MAP

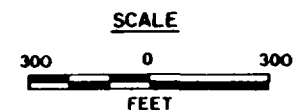


FIGURE 2

FIGURE 3

NL INDUSTRIES, INC.  
GRANITE CITY SITE  
GRANITE CITY, ILLINOIS

# SITE PLAN

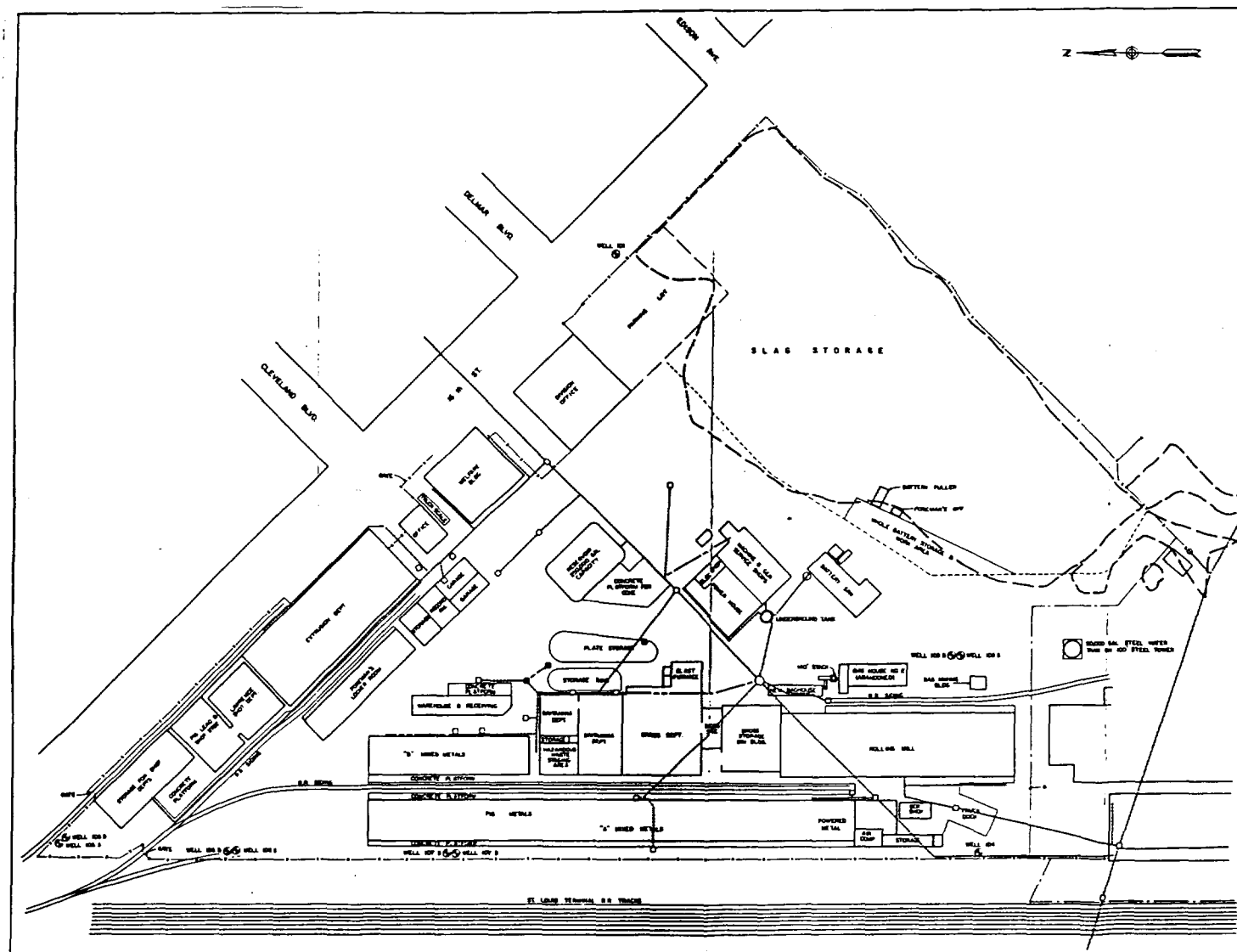
## LEGEND

- APPROXIMATE LIMITS OF SLAG PILE
- COMBINED SEWER
- INACTIVE SEWER
- CATCHBASIN
- ABANDONED CATCHBASIN

NOTE: LIMITS OF SLAG PILE DETERMINED FROM A  
AND GSP TOPOGRAPHIC SURVEY BY SHERRILL,  
KORSHAK, & SCHWAB, INC.

SCALE  
1" = 20'

**O'BRIEN & GERE**  
O'Brien & Gere Engineers, Inc.



# PROCESS FLOW DIAGRAM FOR TARACORP SECONDARY LEAD SMELTER PRIOR TO FEB. 1983

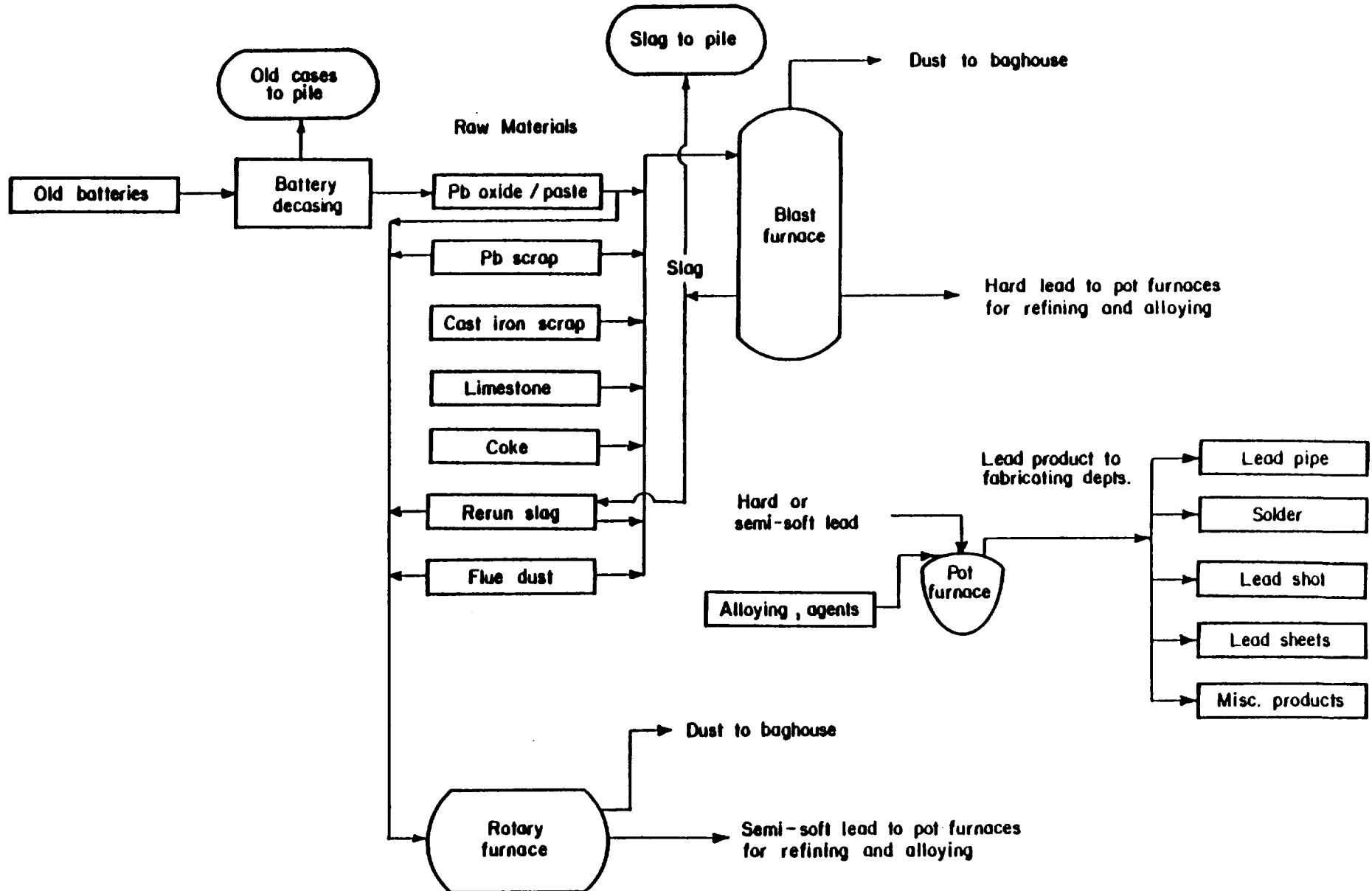
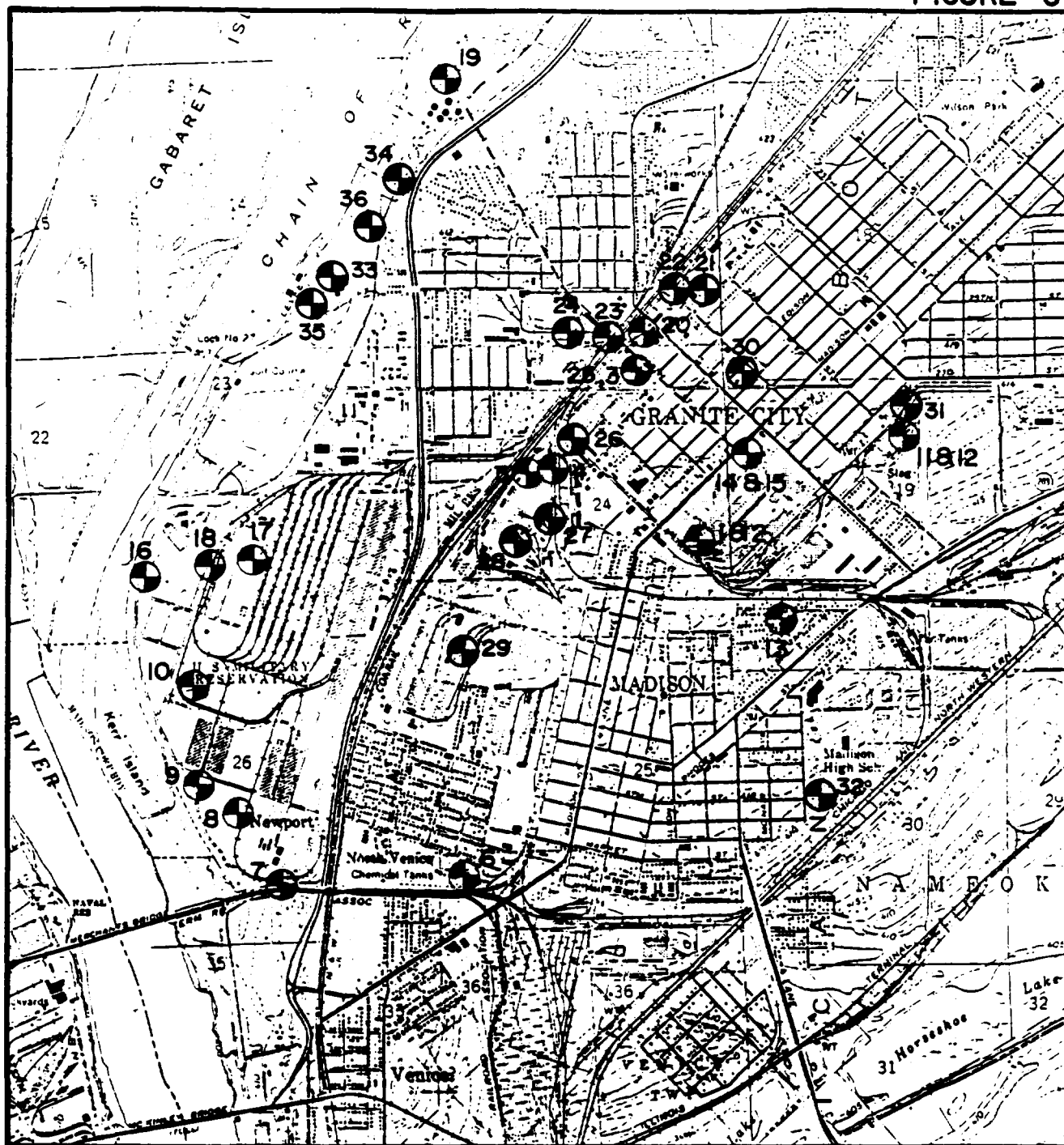


FIGURE 4

FIGURE 5



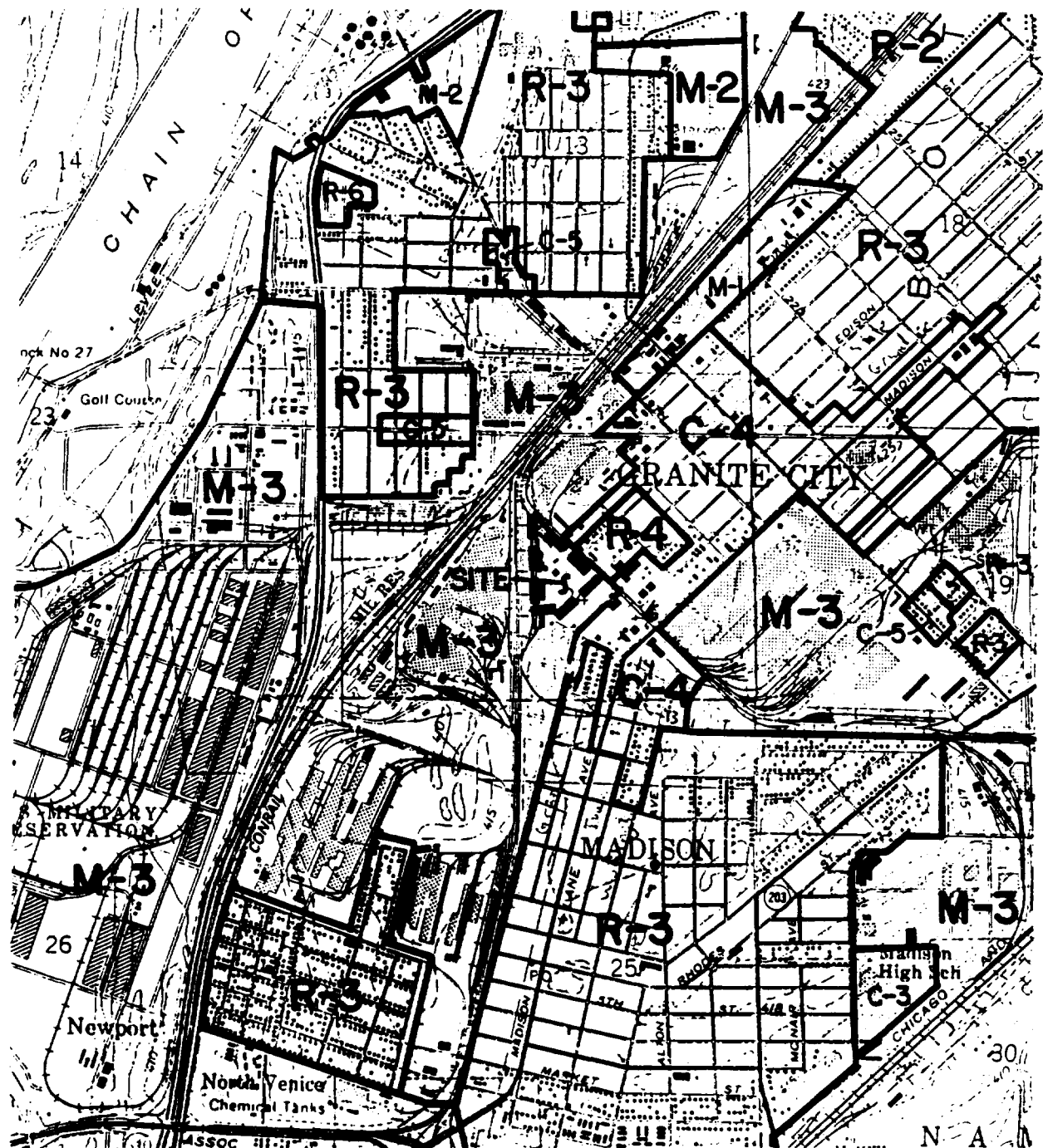
NL INDUSTRIES  
GRANITE CITY SITE  
GRANITE CITY, ILL.  
**LOCAL WELLS**

LEGEND

● WELL LOCATION (APPROX.)

3000 0 3000  
SCALE IN FEET

# NL INDUSTRIES GRANITE CITY SITE LAND USE MAP

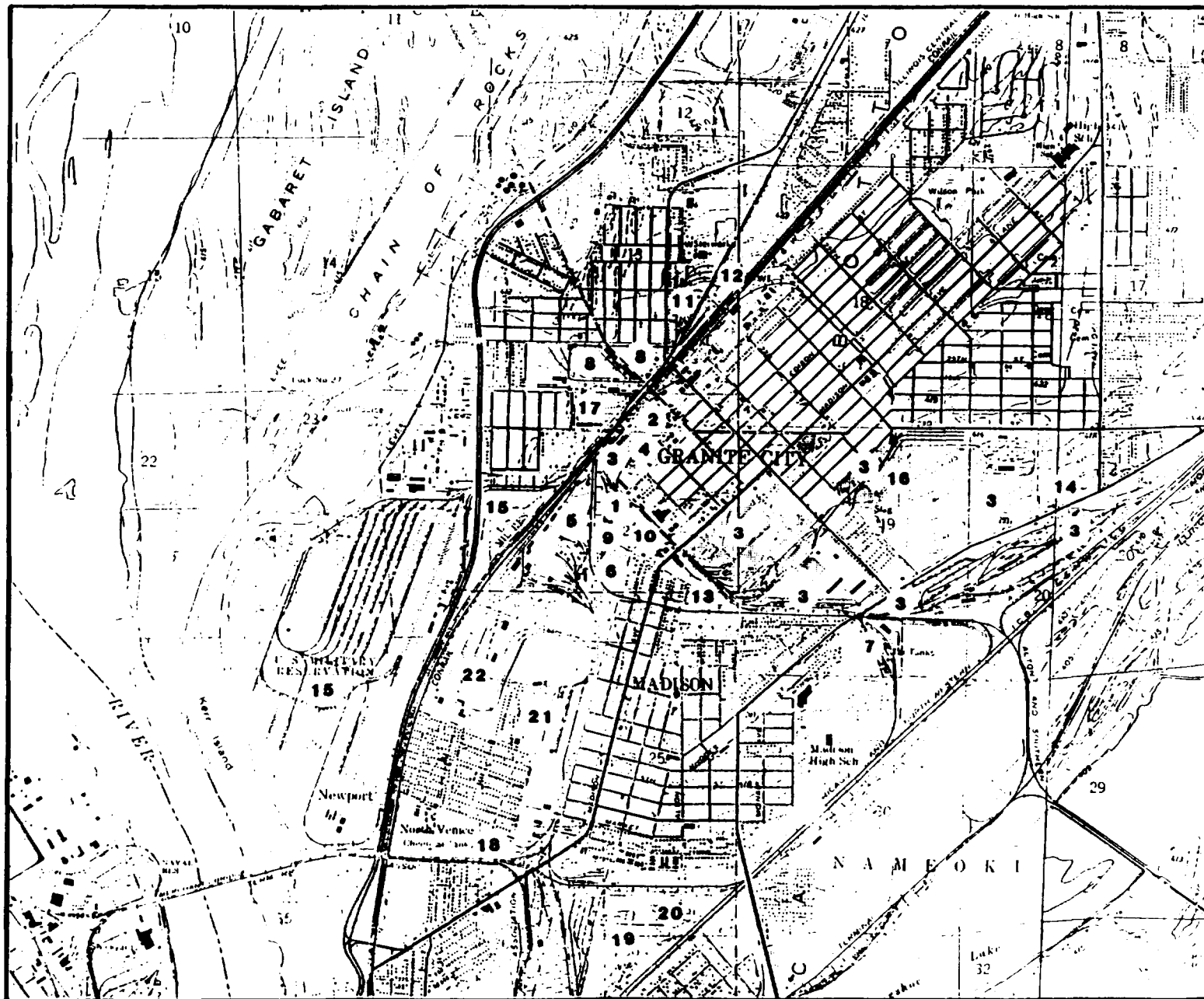


## LEGEND

R-1 SINGLE FAMILY RESIDENCE	C-1 OFFICE COMMERCIAL
R-2 SINGLE FAMILY RESIDENCE	C-2 NEIGHBORHOOD COMMERCIAL
R-3 SINGLE FAMILY RESIDENCE	C-3 COMMUNITY SERVICE
R-4 TWO FAMILY RESIDENCE	C-4 CENTRAL BUSINESS COMMERCIAL
R-5 MULTI-FAMILY RESIDENCE	C-5 HIGHWAY COMMERCIAL
R-6 MOBILE HOME RESIDENCE	C-6 PLANNED COMMERCIAL
M-1 WAREHOUSE INDUSTRIAL	M-3 HEAVY INDUSTRIAL
M-2 LIGHT INDUSTRIAL	M-4 PLANNED INDUSTRIAL

SCALE IN MILES





NL INDUSTRIES  
GRANITE CITY SITE  
GRANITE CITY, ILLINOIS

INDUSTRIES IN  
VICINITY OF  
GRANITE CITY SITE

LEGEND

INDUSTRIES IN THE VICINITY OF  
THE NL GRANITE CITY SITE

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1/2

3/4

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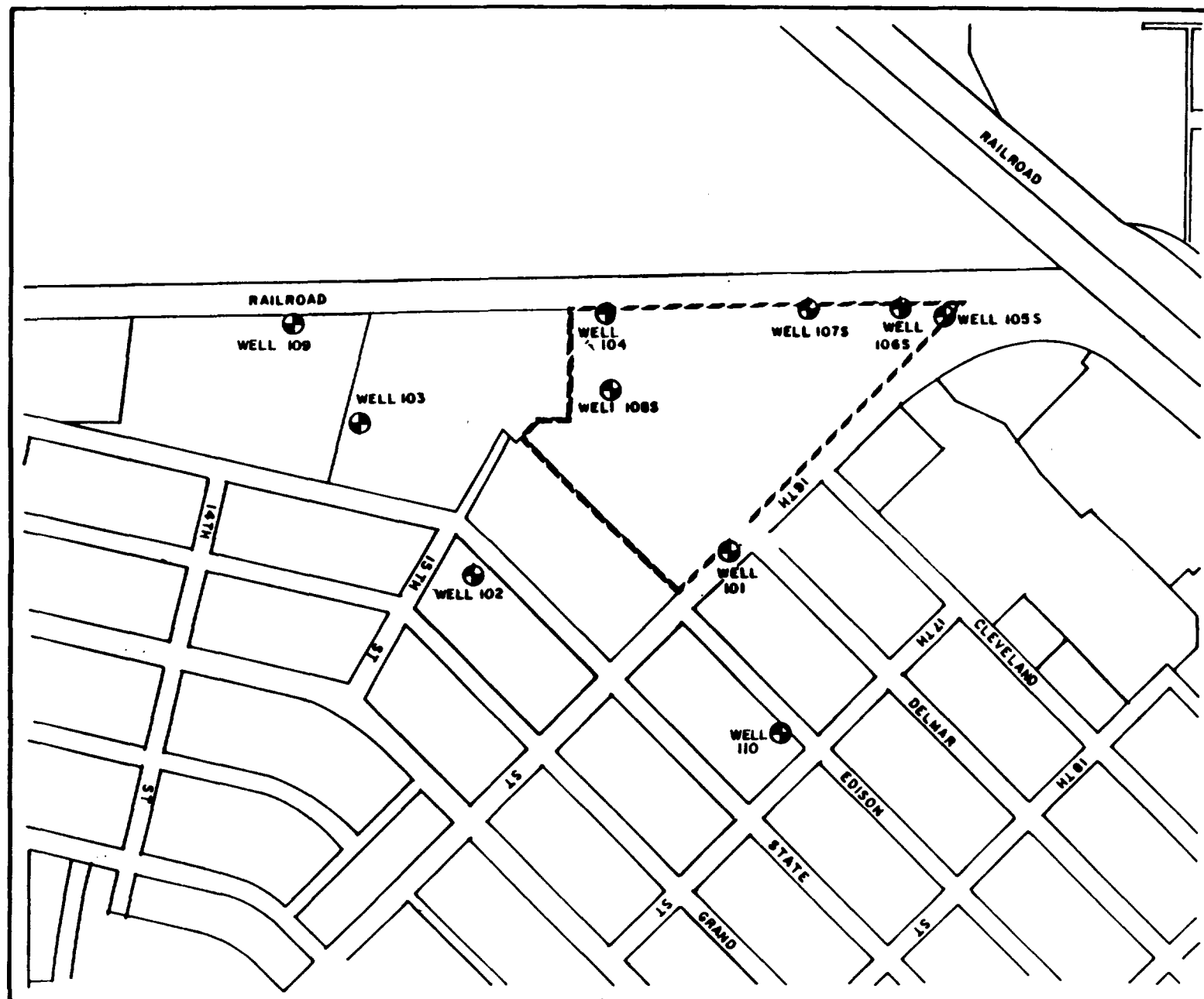
68 1/2

68 3/4

69

69 1/4

69 1/2



NL INDUSTRIES  
GRANITE CITY SITE  
GRANITE CITY, ILLINOIS

# WELL LOCATION MAP

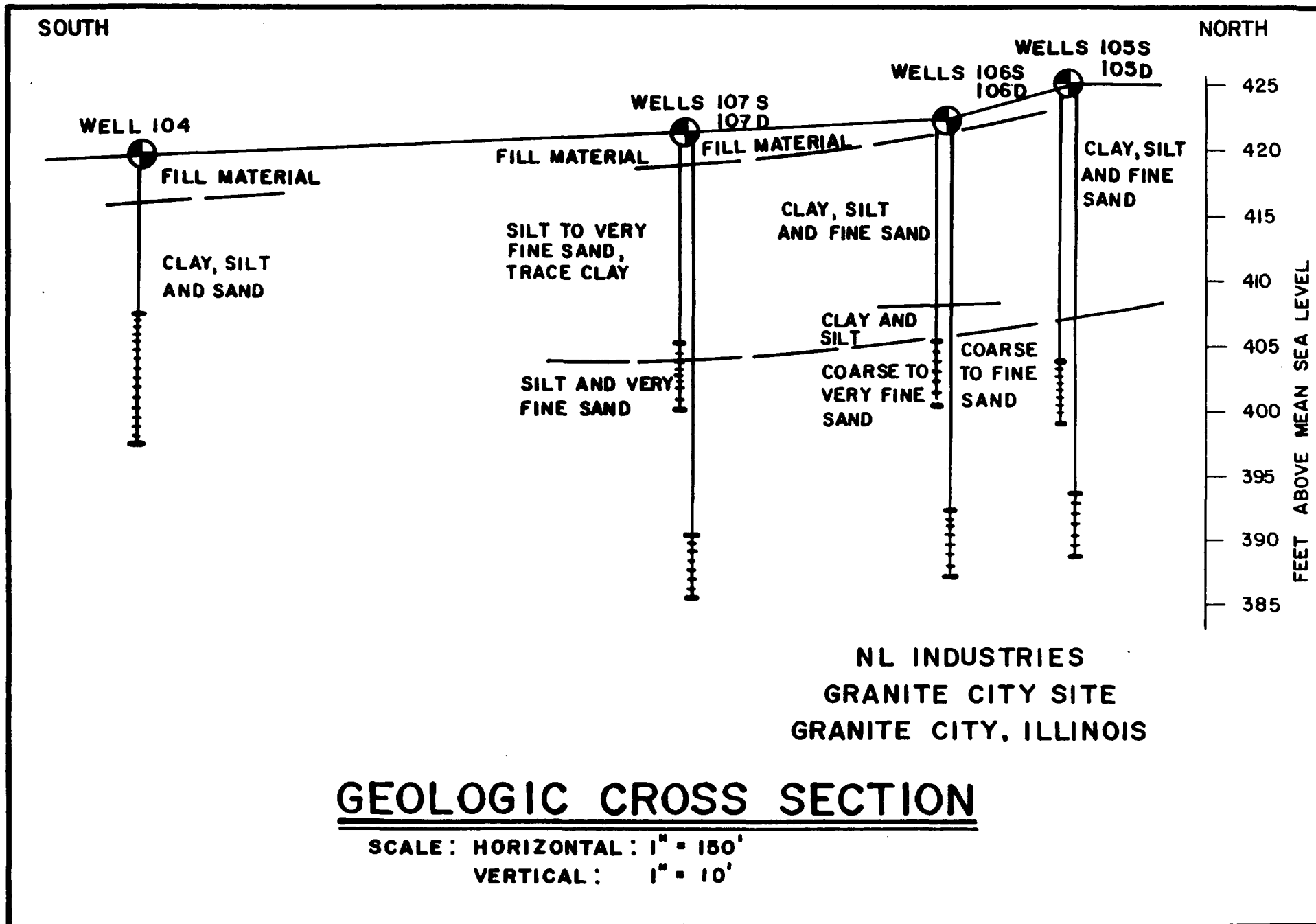
## LEGEND

- WELL 101 GROUNDWATER MONITOR WELL & GROUNDWATER
- SITE PERIMETER

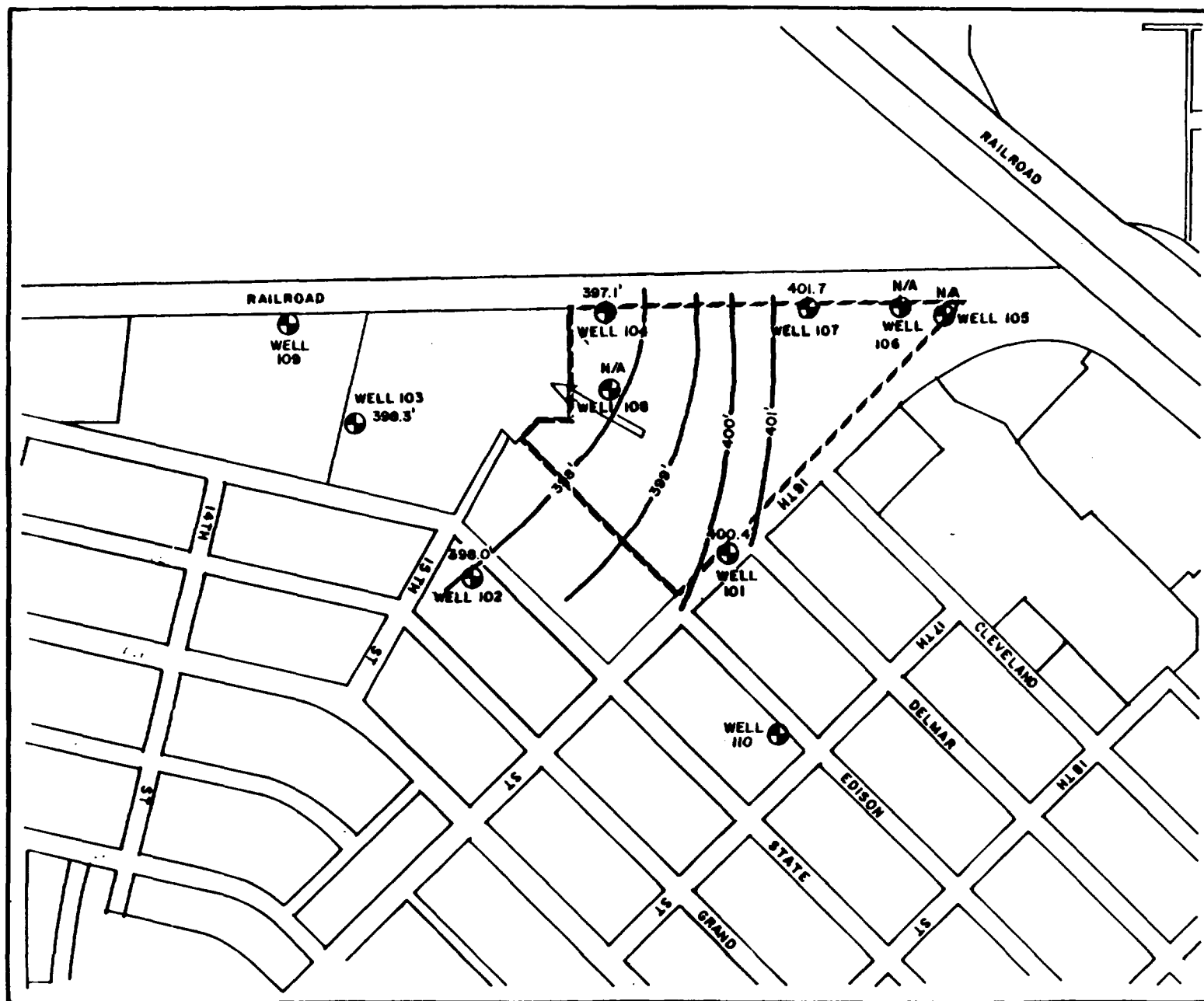
## SCALE



FIGURE 8



**FIGURE 9**







NL INDUSTRIES  
GRANITE CITY SITE  
GRANITE CITY, ILLINOIS

## GROUNDWATER ELEVATION MAP

(SHALLOW WELLS)  
10/87

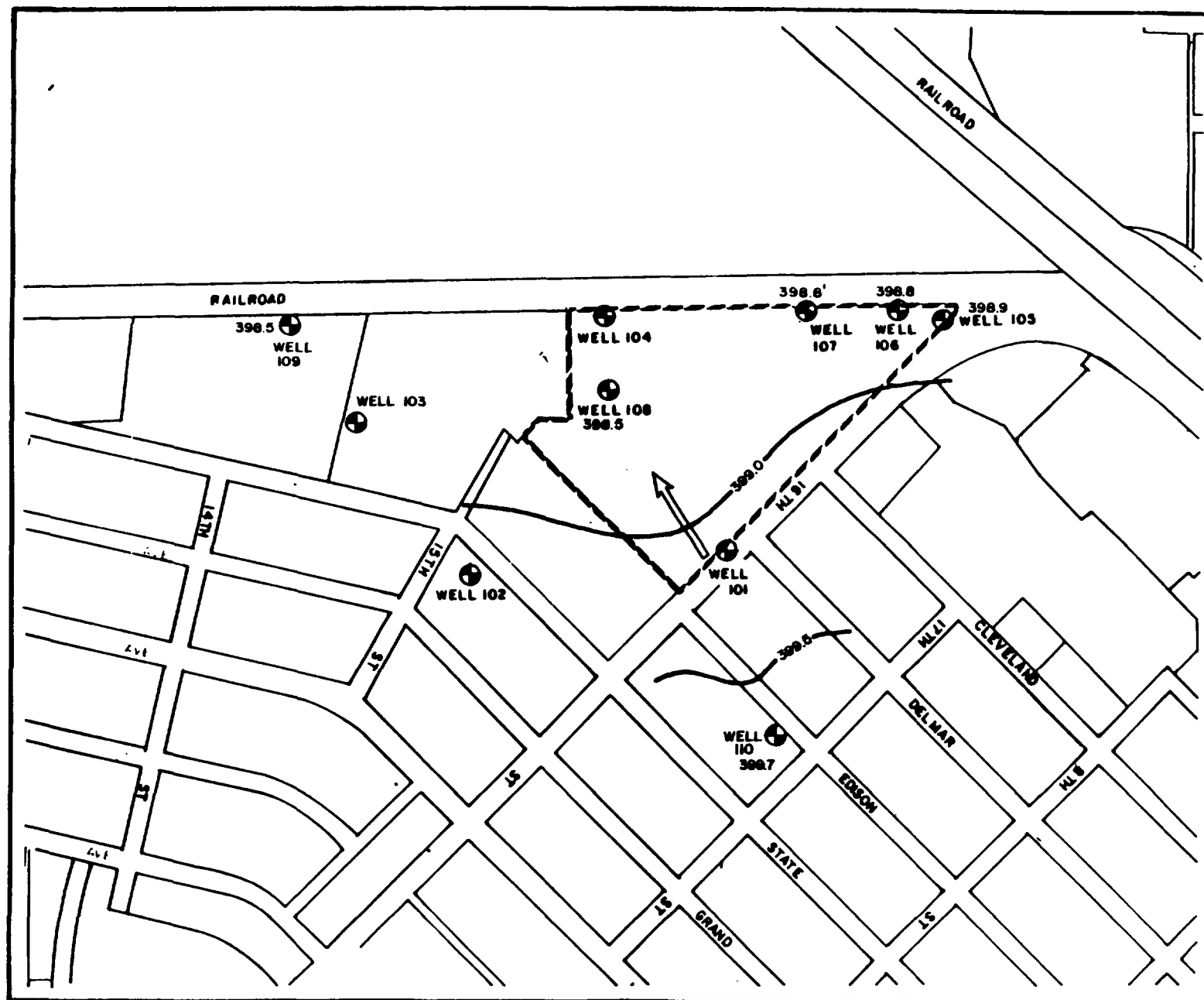
### LEGEND

- 401.15'  GROUNDWATER MONITOR WELL & GROUNDWATER ELEVATIONS FOR SHALLOW WELLS (10/87)
-  GROUNDWATER CONTOURS
-  GROUNDWATER FLOW DIRECTION
-  SITE PERIMETER

### SCALE



 O'BRIEN & GERE



NL INDUSTRIES  
GRANITE CITY SITE  
GRANITE CITY, ILLINOIS

## GROUNDWATER ELEVATION MAP

(DEEP WELLS)  
10/87

### LEGEND

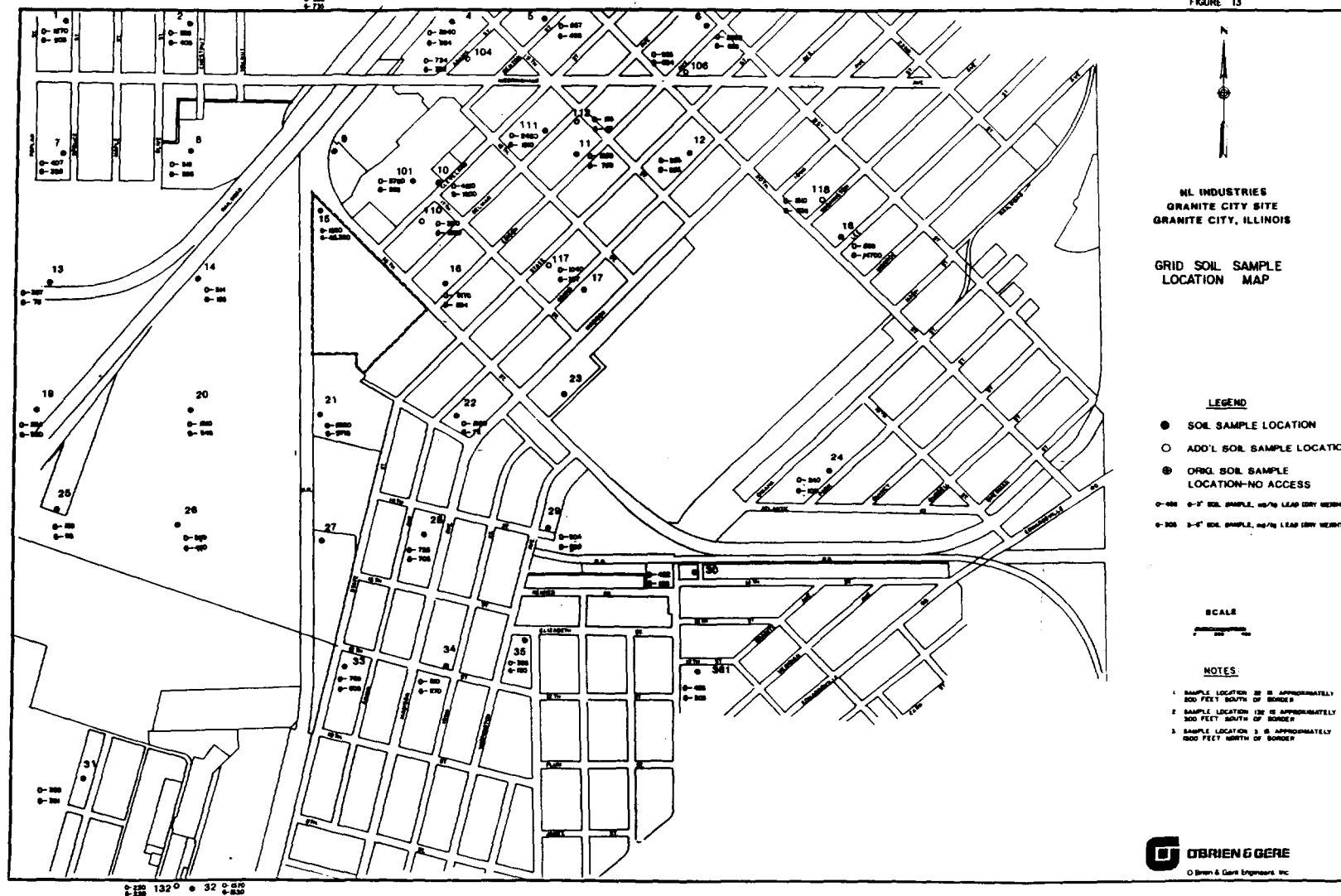
- 401.15' GROUNDWATER MONITOR WELL & GROUNDWATER ELEVATIONS FOR DEEP WELLS (10/87)
- GROUNDWATER CONTOUR
- GROUNDWATER FLOW DIRECTION
- SITE PERIMETER

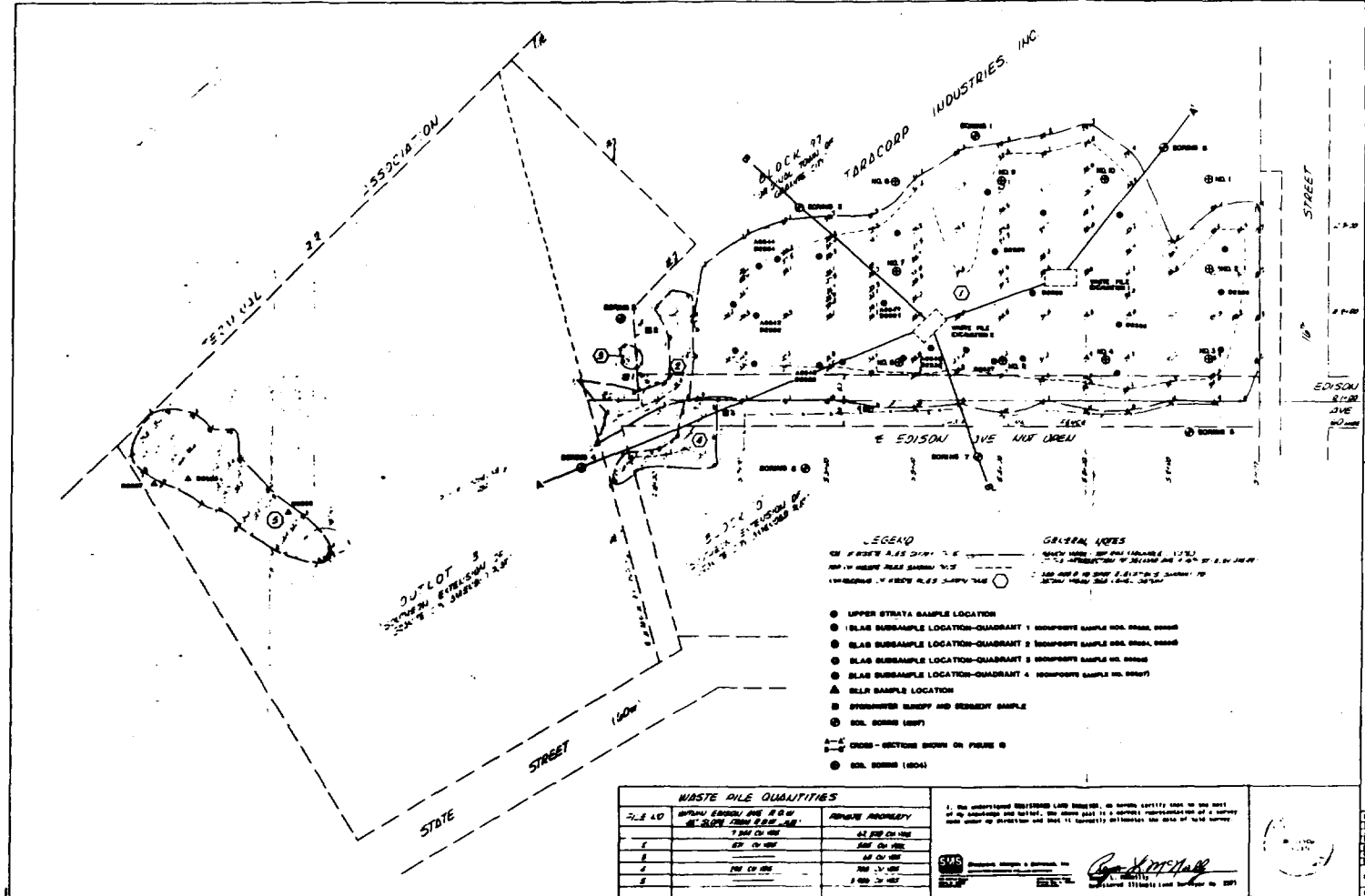
### SCALE



GDBRIN & SONS

FIGURE 13





**SMS**  
Sheppard Morgan & Schwab, Inc.  
CORPORATION  
1111 N. 1ST ST., SUITE 100  
MADISON, WISCONSIN 53703

PLAT SHOWING TORGACORP'S WASTE PILES IN FIVE WASTE PILES LOCATED IN SECTION 18, T4U, R10W, OF THE THIRD PRINCIPAL MERIDIAN, SENECA CITY, MADISON COUNTY, IL

DATE: 11/1/84  
BY: [Signature]  
SCALE: 1"=50'  
SHEET: 1 OF 1



LABORATORIES, INC.

Page 2

# Laboratory Report

CLIENT NL INDUSTRIES - Granite City JOB NO. 2844.012.517

DESCRIPTION Wells

DATE COLLECTED 1-7,10,17-87 DATE REC'D. 1-29-87 DATE ANALYZED \_\_\_\_\_

	Sample #	LEAD	TOTAL DISSOLVED SOLIDS	SULFATE
C101 - 41010	D3900	-	590.	150.
C102 - 41020	D3902	-	640.	120.
103 - 41030	D3904	-	500.	210.
C104 - 41040	D3906	-	360.	120.
C105S - 41051	D3908	-	1000.	320.
C105D - 41059	D3910	-	660.	140.
106S - 41061	D3912	-	1100.	290.
C106D - 41069	D3914	-	600.	160.
C107S - 41071	D3916	-	820.	260.
C107D - 41079	D3918	-	1370.	540.
C108S - 41081	D3920	-	3110.	1250.
C108D - 41089	D3922	-	3860.	1560.
102 - 410202	D3924	0.68	-	-
C106D - 410692	D3925	0.50	-	-
108S - 410812	D3926	0.50	-	-

Methodology: Federal Register — 40 CFR, Part 135, October 26, 1984

Units: mg/l ppm, unless otherwise noted

Comments:

CBG Laboratories, Inc.  
Box 4942 • 1304 Buellev Rd. / Syracuse, NY 13201 • 315-457-1224

Authorized: D. J. Borden

Date: May 14, 1987



## Laboratory Report

CLIENT NL INDUSTRIES JOB NO. 2844.012.517

DESCRIPTION Waters

Sample Type 4

DATE COLLECTED 4-6,7,8-87 DATE REC'D 4-16-87 DATE ANALYZED \_\_\_\_\_

Description	ID1 102	ID2 00	ID1 101	ID2 00	ID1 107	ID2 11	ID1 107	ID2 99	ID1 106	ID2 99	ID1 105	ID2 99	ID1 108	ID2 99	ID1 103	ID2 00	ID1 104	ID2 00
Sample #	D5680		D5681		D5682		D5683		D5684		D5685		D5686		D5687		D5688	
TOTAL LEAD	0.28		-		-		-		0.72		-		0.22		-		-	
LEAD, FILTERED	<0.005		<0.005		<0.005		<0.005		0.013		<0.005		0.009		<0.005		<0.005	
CADMIUM, FILTERED	<0.001		<0.001		<0.001		<0.001		0.002		<0.001		5.2		0.002		<0.001	
BARIUM, FILTERED	<1.		<1.		<1.		<1.		<1.		<1.		<1.		<1.		<1.	
ARSENIC, FILTERED	<0.005		0.070		<0.005		0.014		<0.005		<0.005		<0.005		<0.005		<0.005	
IRON, FILTERED	<0.1		20.		<0.1		8.1		<0.1		<0.1		<0.1		<0.1		<0.1	
ZINC, FILTERED	<0.05		<0.05		<0.05		<0.05		<0.05		<0.05		44.		<0.05		<0.05	
MANGANESE, FILTERED	0.124		4.22		0.139		0.422		0.359		0.284		29.4		<0.025		0.026	
NICKEL, FILTERED	<0.01		<0.01		<0.01		<0.01		<0.01		<0.01		0.70		<0.01		<0.01	
COPPER, FILTERED	<0.01		<0.01		<0.01		<0.01		<0.01		<0.01		<0.01		<0.01		<0.01	
TOTAL DISSOLVED SOLIDS	610.		530.		850.		300.		770.		620.		1400.		550.		400.	
SULFATE	210.		190.		300.		550.		260.		180.		850.		170.		130.	
CHROMIUM	<0.005		<0.005		<0.005		<0.005		<0.005		<0.005		<0.005		<0.005		<0.005	
MERCURY	<0.0005		<0.0005		<0.0005		<0.0005		<0.0005		<0.0005		<0.0005		<0.0005		<0.0005	
ANTIMONY	<0.02		<0.02		<0.02		<0.02		<0.02		<0.02		<0.02		<0.02		<0.02	
SILVER	<0.005		<0.005		<0.005		<0.005		<0.005		<0.005		<0.005		<0.005		<0.005	
SELENIUM	<0.002		<0.002		<0.002		<0.002		0.003		<0.002		<0.002		0.003		0.003	

Methodology: Federal Register — 40 CFR, Part 136, October 26, 1984

Units: mg/l (ppm) unless otherwise noted

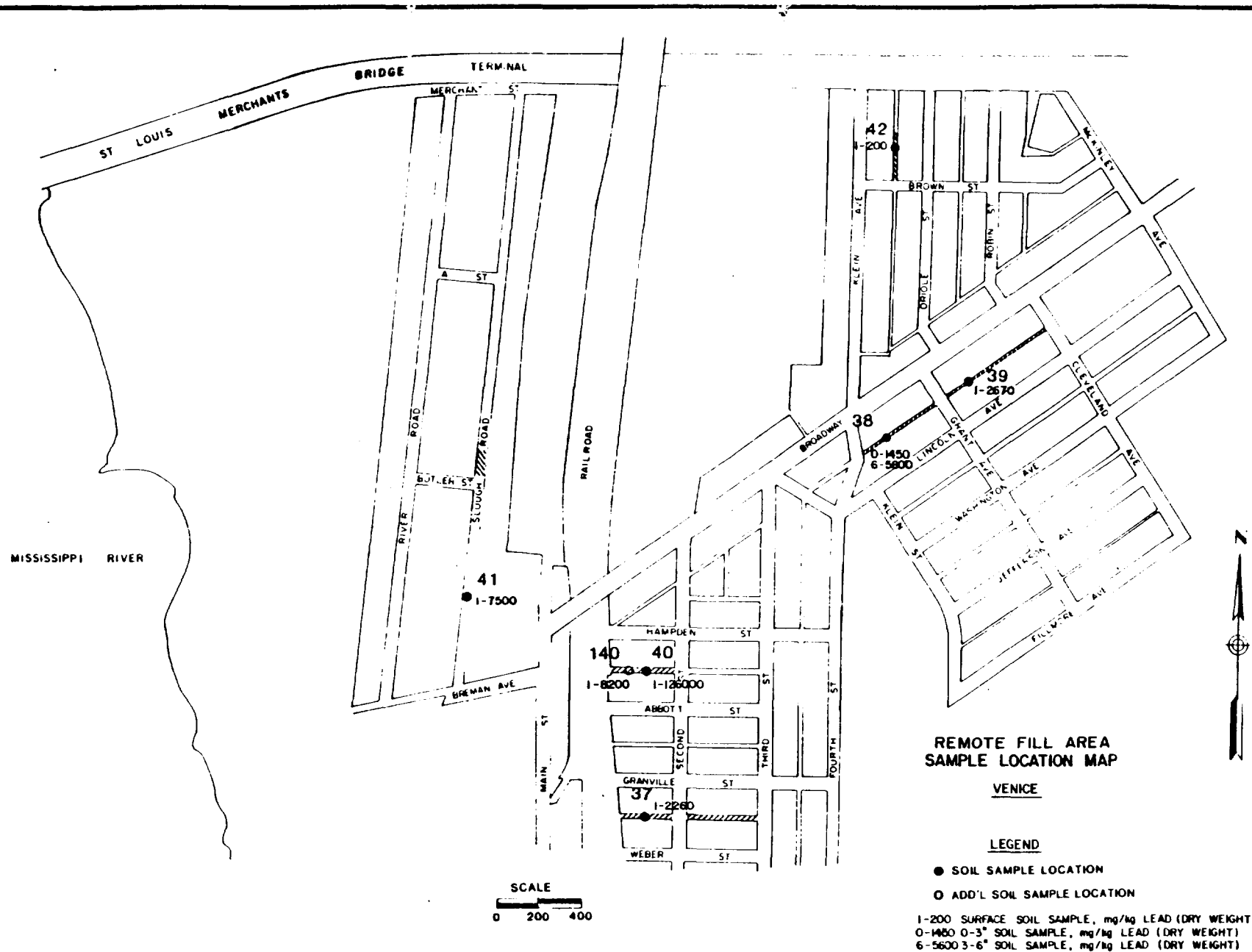
Comments:

OGC Laboratories, Inc.  
Box 4942 / 1304 Buckley Rd / Syracuse, NY 13221 / (315) 457-1414

Authorized:

*D. A. Bender*

Date: May 20, 1987



**FIGURE 14**

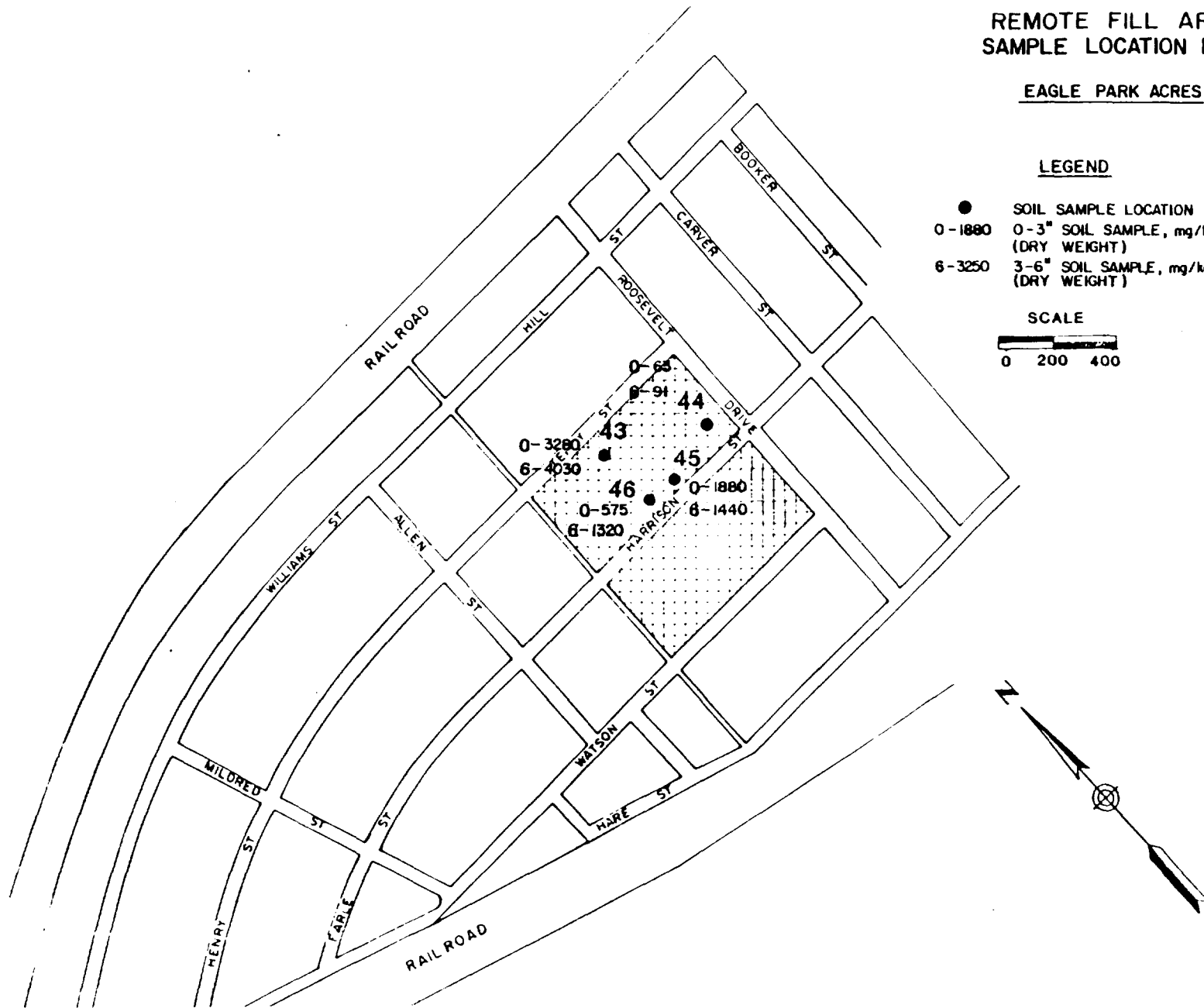
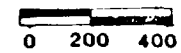
# REMOTE FILL AREA SAMPLE LOCATION MAP

EAGLE PARK ACRES

## LEGEND

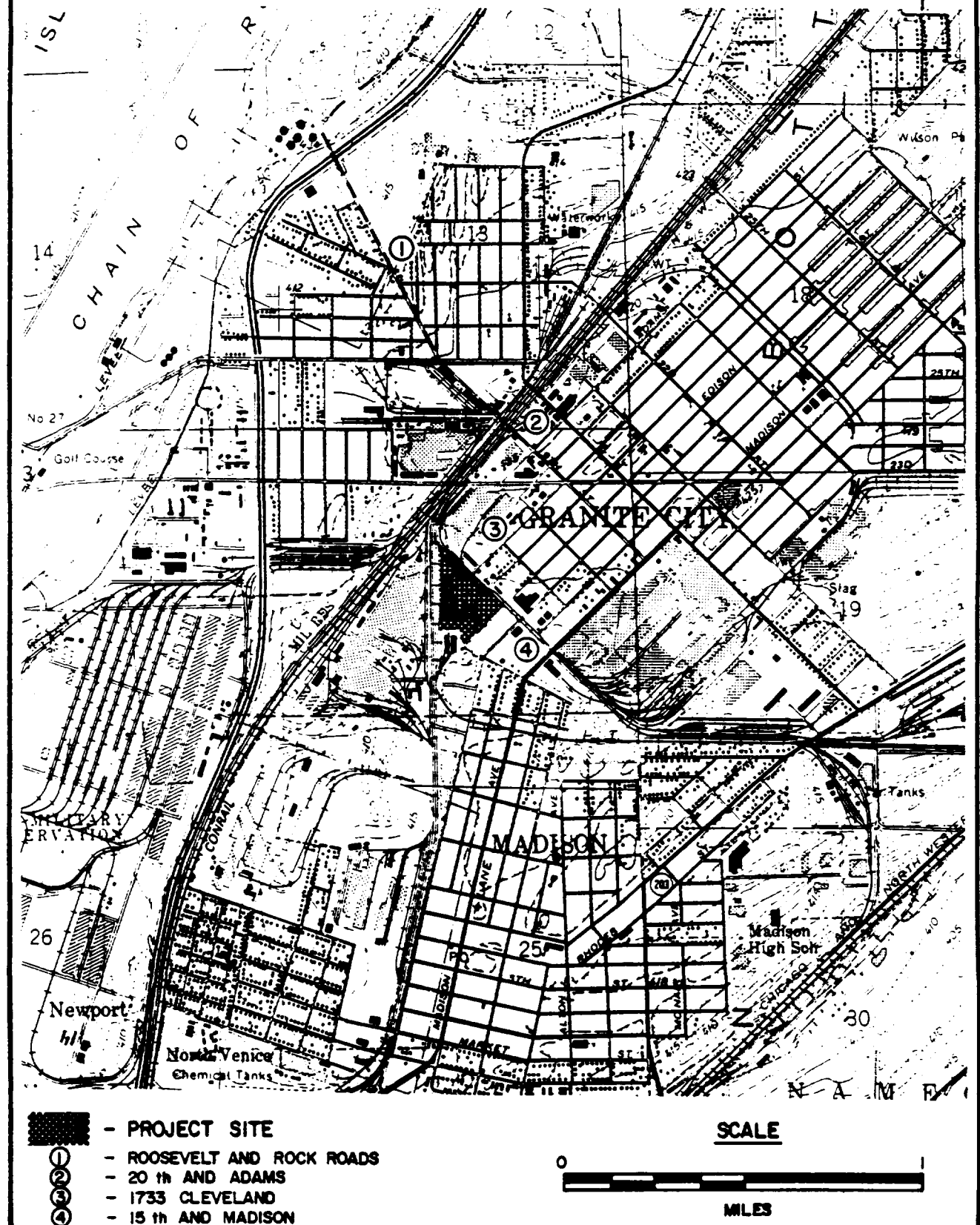
- SOIL SAMPLE LOCATION
- 0-1880 0-3" SOIL SAMPLE, mg/kg LEAD (DRY WEIGHT)
- 6-3250 3-6" SOIL SAMPLE, mg/kg LEAD (DRY WEIGHT)

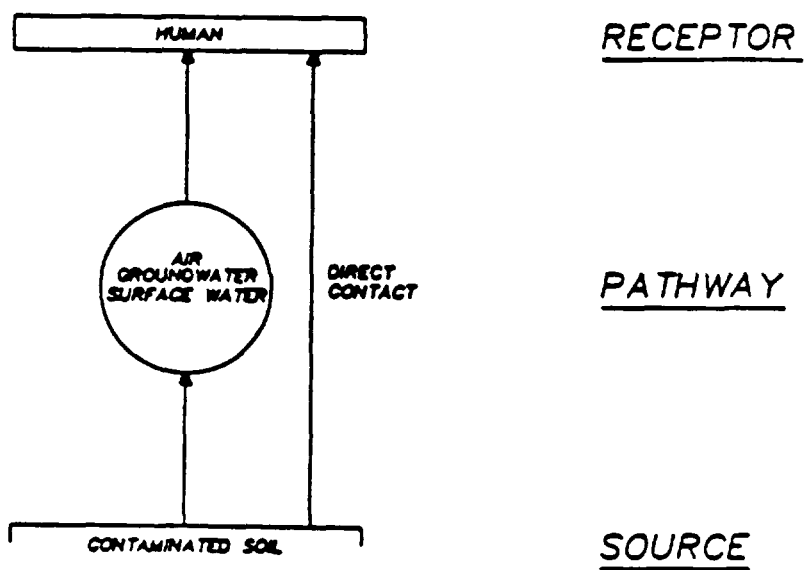
## SCALE



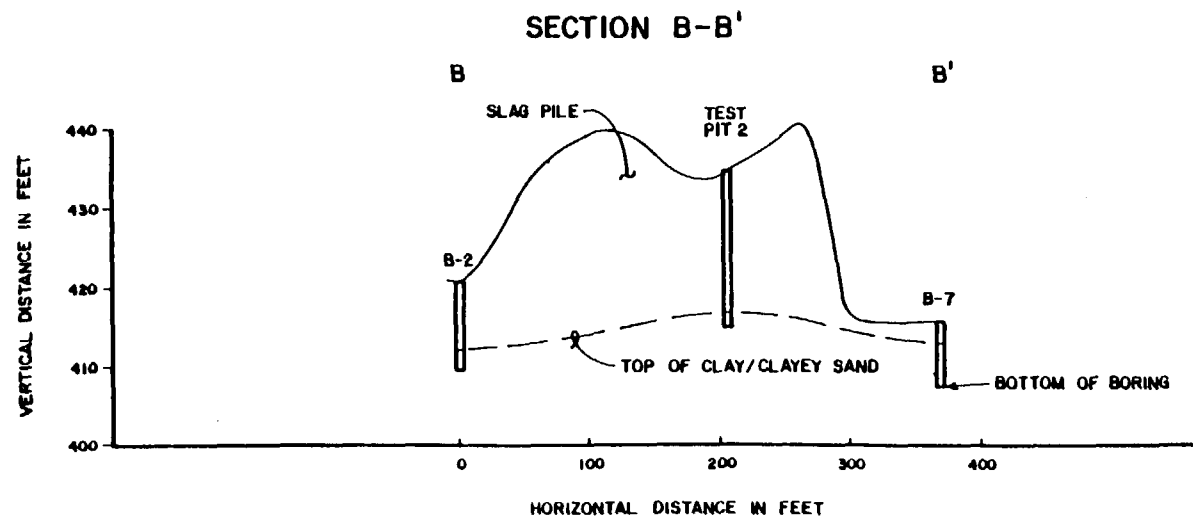
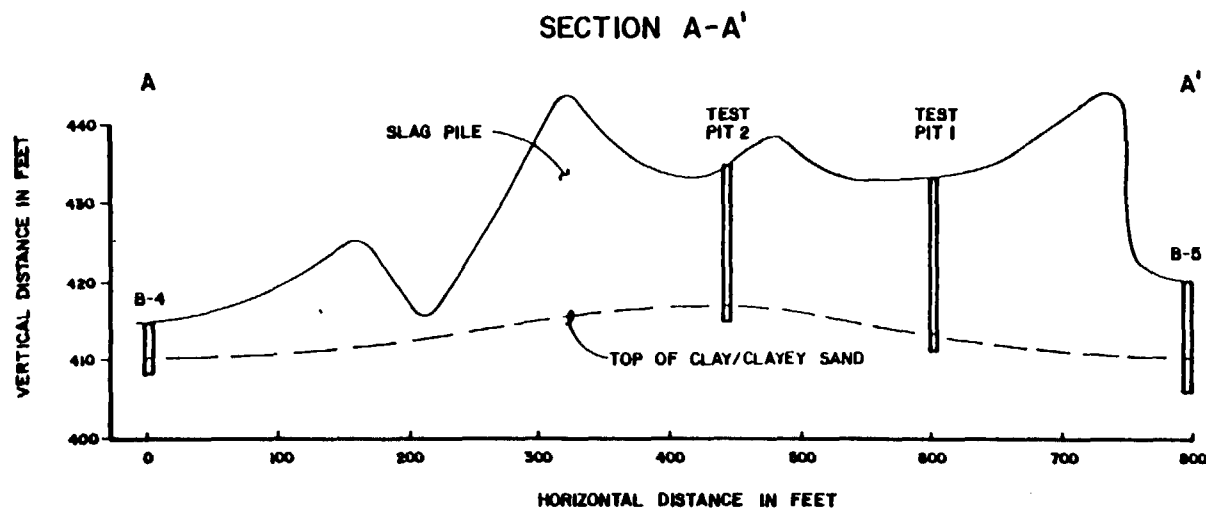
NL INDUSTRIES  
GRANITE CITY SITE  
GRANITE CITY, ILLINOIS

## IEPA AMBIENT AIR MONITORING LOCATIONS





**Basic Exposure Pathways**



NL INDUSTRIES  
GRANITE CITY SITE  
GRANITE CITY, ILLINOIS

## SLAG PILE CROSS-SECTIONS

(SECTION LOCATIONS SHOWN  
ON FIGURE 12)

**FIGURE 18**

**APPENDIX A**  
**SUMMARY OF REGULATORY RESPONSE ACTIONS**

<u>Date</u>	<u>Description of Response Action and Reference Document</u>
1973	IEPA issued operating permit for blast furnace to NL. Documented in IEPA Memorandum from Tony Telford, IEPA, to Tom Bierman, Bharat Mathur, Steve Tamplin, and B. Sharpe, all from IEPA, dated 3/1/83.
9/17/75	IEPA plant visit to gain familiarity with NL's operations. Two problems were noted: 1) noise from battery case sawing, and 2) acid leaching from a stockpile of battery cases. Documented in IEPA Memorandum from Richard Jennings, IEPA, to Walter H. Franke, IEPA dated 11/10/75.
8/3/77	IEPA plant inspection found NL to be in violation of environmental regulations due to operation of a battery acid reclaiming system without an operating permit. Documented in IEPA letter from Walter H. Franke, Supervisor, Region IV, Division of Air Pollution Control, IEPA, to Keith Cutler, NL, dated 9/27/77.
1/79	NL sells facility to Taracorp.
12/12/79	IEPA plant inspection. Documented in IEPA Memorandum from Jeff Benbenek, IEPA to Steve Tamplin, IEPA dated 10/4/82.
4/7/80	IEPA plant inspection. Documented in IEPA Memorandum from Jeff Benbenek, IEPA to Steve Tamplin, IEPA dated 10/4/82.
5/22/80	IEPA plant inspection. IEPA and Taracorp discussed the SIP. Documented in IEPA Memorandum from Jan Horton, IEPA SIP Coordinator, to File, dated 7/29/80, and IEPA Memorandum from Jeff Benbenek, IEPA to Steve Tamplin, IEPA dated 10/4/82.
7/15/80	Meeting between IEPA and Taracorp regarding SIP. Documented in IEPA Memorandum from Jan Horton, IEPA SIP Coordinator, to File, dated 7/29/80.
7/10/81	IEPA plant inspection. Documented in IEPA Memorandum from Jeff Benbenek, IEPA, to Steve Tamplin, IEPA, dated 10/4/82.
10/6/81	IEPA plant inspection for compliance with RCRA. Management of waste pile was in question based on the plan inspection. Documented in RCRA Inspection Report by Diane M. Spencer, IEPA, dated 10/6/81.
10/22/81	IEPA plant inspection. Documented in IEPA Memorandum from Jeff Benbenek, IEPA to Steve Tamplin, IEPA, dated 10/4/82.

5/28/82 IEPA plant inspection. Facility was found to be in violation of Rule 103 (b). Documented in IEPA Memorandum from Jeff Benbenek, IEPA, to Steve Tamplin, IEPA, dated 10/4/82.

6/4/82 Warning letter sent from IEPA to Taracorp regarding the violation of Rule 103 (b). Documented in IEPA Memorandum from Jeff Benbenek, IEPA, to Steve Tamplin, IEPA, dated 10/4/82.

6/8/82 Written response from Taracorp to IEPA regarding IEPA's letter of 6/4/82. Documented in IEPA Memorandum from Jeff Benbenek, IEPA, to Steve Tamplin, IEPA, dated 10/4/82.

7/9/82 IEPA plant inspection. Documented in IEPA Memorandum from Jeff Benbenek, IEPA, to Steve Tamplin, IEPA, dated 10/4/82.

7/19/82 Compliance Inquiry Letter from IEPA to Taracorp regarding violations of Rules 203 (a) and 105 (a). Documented in IEPA Memorandum from Jeff Benbenek, IEPA to Steve Tamplin, IEPA, dated 10/4/82.

7/27/82 Written response form Taracorp to IEPA regarding IEPA's Compliance Inquiry Letter of 7/19/82. Documented in IEPA Memorandum from Jeff Benbenek, IEPA to Steve Tamplin, IEPA, dated 10/4/82.

9/2/81 IEPA plant inspection. Facility was found to be in violation of several environmental regulations. Documented in IEPA letter from Delbert D. Haschmeyer, Deputy Director, IEPA, to John Wentz, Manager of Environmental Control, Taracorp, dated 9/17/82.

9/3/82 IEPA inspection of SLLR. Facility was found to be in violation of several environmental regulations. Documented in IEPA letter from Delbert D. Haschmeyer, Deputy Director, IEPA, to James Stack, Plant Manager, Battery Recyclers of Granite City (SLLR), dated 9/17/82.

10/28/82 IEPA observation of Taracorp monitoring well installation. Documented in IEPA Observation Report by Diane M. Spencer, IEPA, dated 10/28/82.

2/2/83 IEPA evaluation of Taracorp relative to permit applications. Documented in IEPA Memorandum from Joe Ajayi, IEPA and Tony Telford, IEPA, to Dharat Mathur, IEPA, dated 2/15/83.

2/25/83 IEPA denial of Taracorp Construction Permit Application and several Operating Permit Applications. Documented in IEPA letter from Thomas G. McSwiggan, Manager, Permit Section, Div. of Water Pollution Control, IEPA, to John Wentz, Taracorp, dated 2/25/83.

- 5/17/83 IEPA meeting with SLLR regarding SLLR allegations that Taracorp had been dumping acid on SLLR/Taracorp property. Documented in IEPA Memorandum from Diane M. Spencer, IEPA, to Div. of Land Pollution Control, IEPA file.
- 6/29/83 IEPA observation of IEPA monitoring well installation. Documented in IEPA Observation Report by Diane M. Spencer, IEPA, dated 6/29/83.
- 7/5/83 IEPA grants Taracorp a permit to operate and oil skimmer in the Extrusion Dept. Documented in IEPA Operating Permit issuance notification to Taracorp from Thomas G. McSwiggan, Manager, Permit Section, Div. of Water Pollution Control, IEPA, dated 7/5/83.
- 8/25/83 IEPA plant inspection to determine if Taracorp had dumped acid from battery breaking operation on property. The inspection revealed no sign of dumping. Documented in IEPA Memorandum from Jeff Benbenek, IEPA to Walter Franke, IEPA, dated 8/30/83.
- 9/9/83 IEPA multimedia plant inspection at Taracorp. The inspection identified evidence of acid drainage in the ditch that receives overflow from the catch basin located west of the battery breaker building. Two sources of acid were determined: 1) nitric acid wash of Sweco screens in the production of powdered lead, which goes to a 4,000 gal. underground storage tank and then to the sewer system; and 2) acid from the battery breaking operation, which goes to the neutralization system. Taracorp filed a RCRA Part A permit on 11/18/80. Documented in IEPA Memorandum from Jeff Benbenek, Inspection Project Coordinator, IEPA, to IEPA Site Clean-Up Technical Panel, dated 9/16/83.
- 11/29/83 IEPA Compliance Inquiry Letter sent to Taracorp. Based on IEPA plant inspection on 9/9/83, Taracorp was found not be to in compliance with the Illinois Environmental Protection Act and Rules. Documented in IEPA letter from Joseph E. Svoboda, Manager Enforcement Programs, IEPA, to George Webb, Director of Environmental Control, Taracorp, dated 11/29/83.
- 1/31/84 Taracorp files an updated RCRA Part A permit with USEPA. Documented in Taracorp letter from George Webb, Director of Environmental Control And Safety, Taracorp, to USEPA Region V, dated 1/31/84.
- 3/16/84 State of Illinois Consent Decree with Taracorp entered in Circuit Court of Madison County. The Consent Decree included all of the items outline in Strategy 6 of the SIP. Consent Decrees also entered between State of Illinois and SLLR, 1st Granite City National Bank (as trustee for

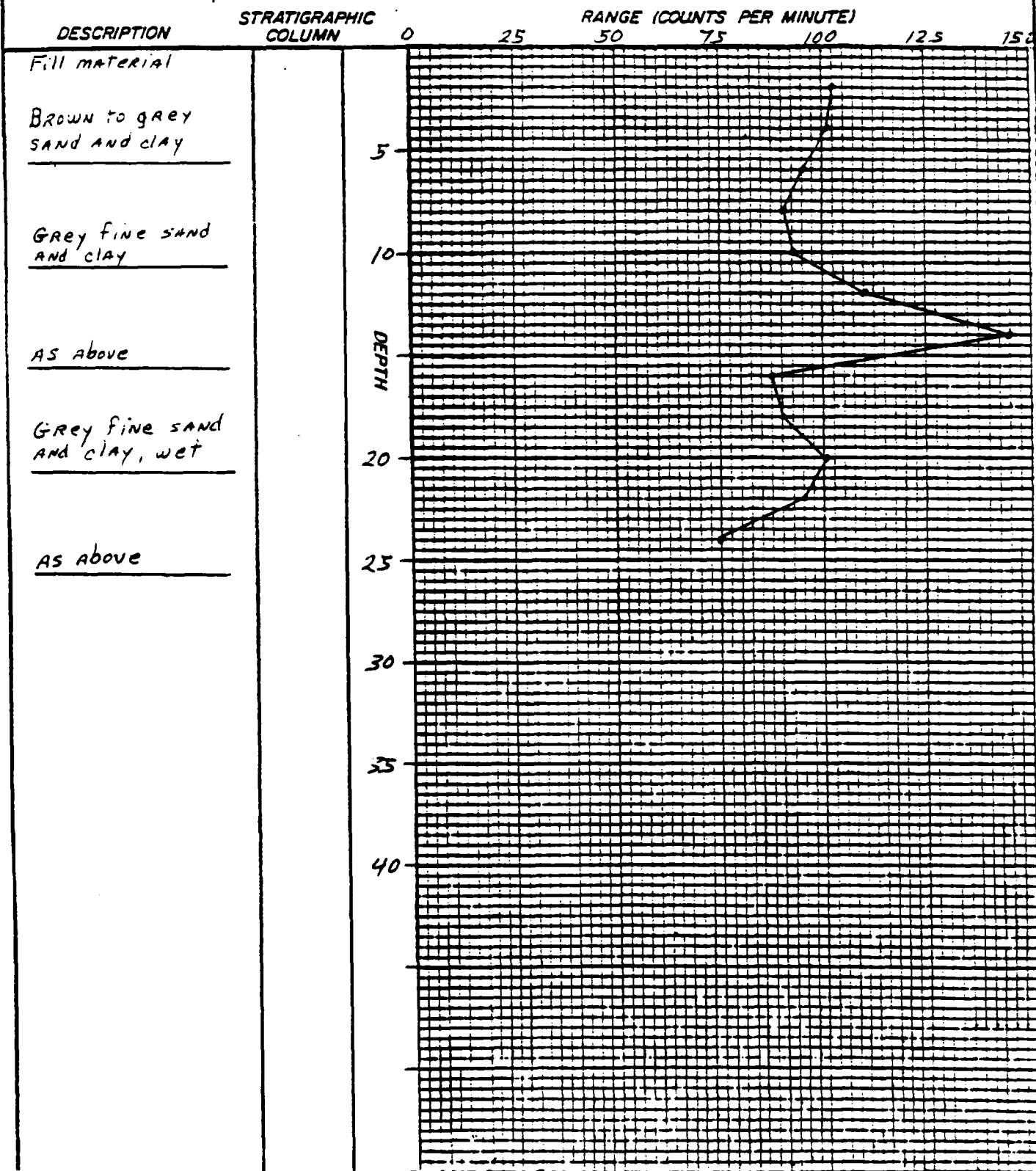
Illinois Land Trust 454), Stackcorp, Inc. and Tri-City Truck Plaza. Documented as attachments to IEPA letter from Daniel J. Goodwin, Manager, Div. of Air Pollution Control, IEPA, to Gary Gulezian, Region V USEPA, dated 3/19/84.

- 5/7/84 IEPA plant inspection relative to Consent Decree requirements. Documented in IEPA Memorandum from Jeff Benbenek, IEPA to Walter Franke, IEPA, dated 5/21/84.
- 5/14/85 Consent Order between USEPA, IEPA and NL Industries to conduct RI/FS effective.
- 6/10/86 Taracorp Site placed on the National Priorities List.

## APPENDIX B

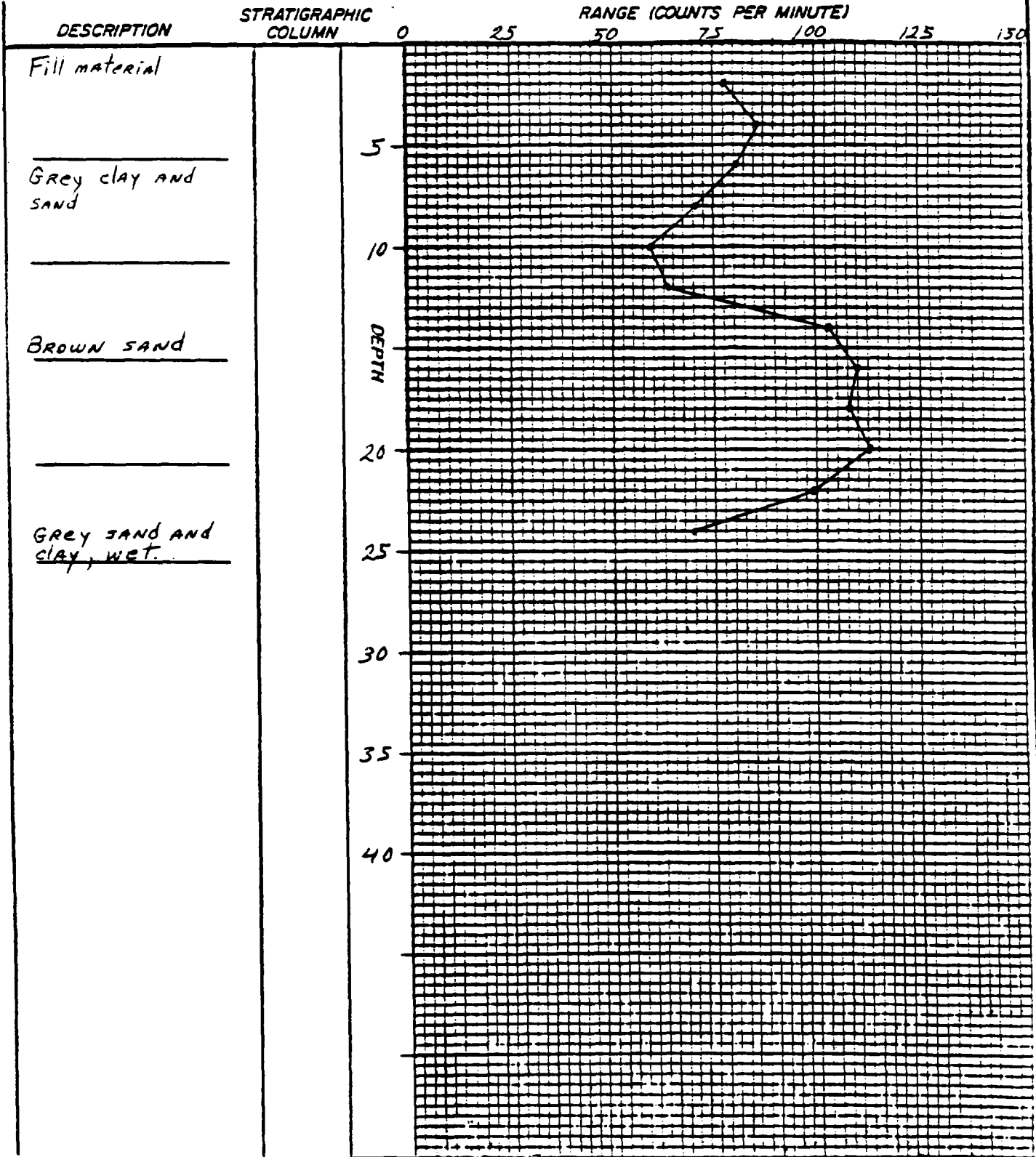
# GAMMA RAY LOG

LOCATION N-L Industries TIME CONSTANT 10 TYPE OF FLUID \_\_\_\_\_  
 LOGGED BY R. Foresti RANGE 200 BORE HOLE 101  
 DATE/TIME 1/8/87 DEPTH TO FLUID \_\_\_\_\_ PROBE TYPE \_\_\_\_\_



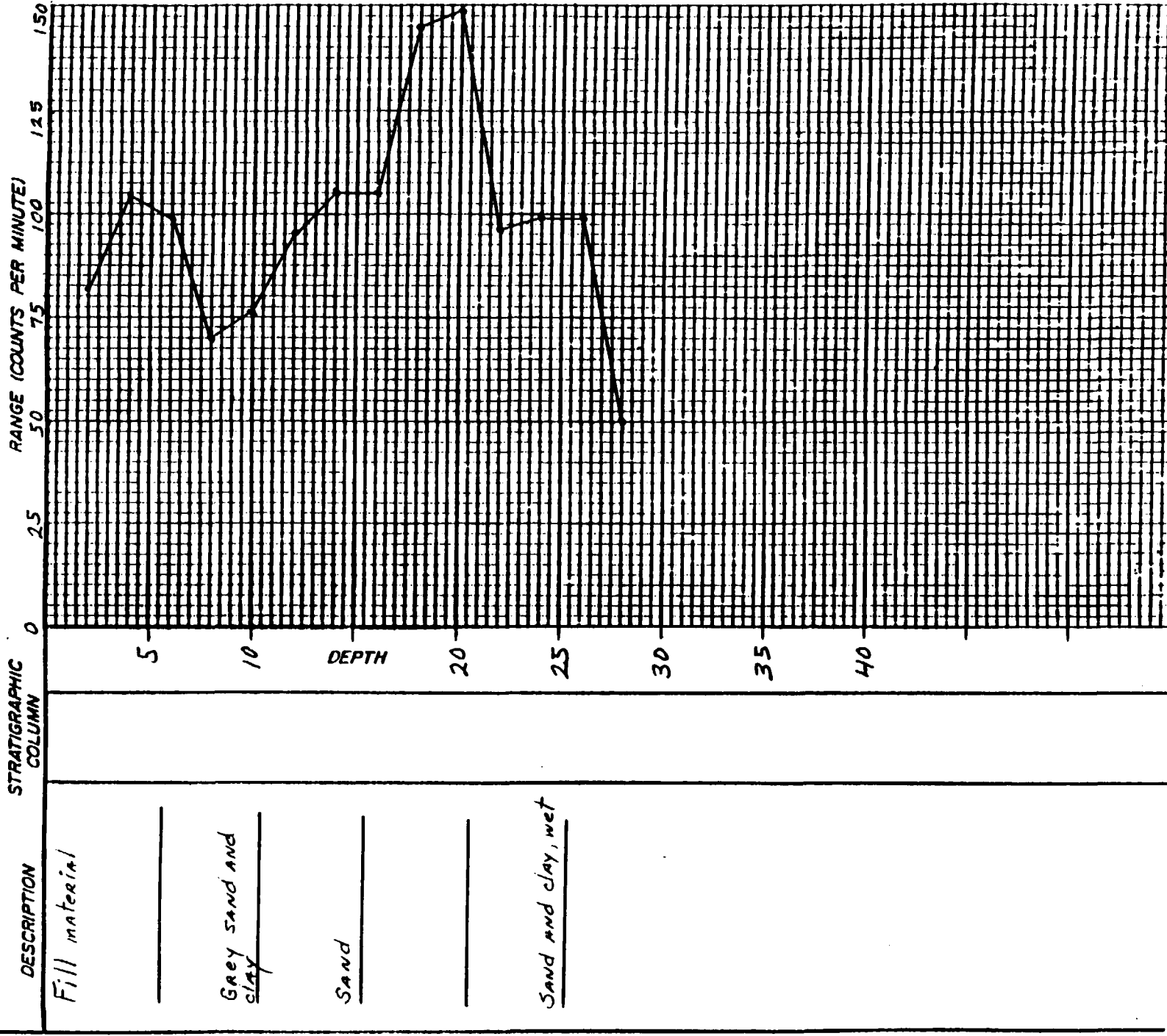
# GAMMA RAY LOG

LOCATION N.L. Industries TIME CONSTANT 10 TYPE OF FLUID \_\_\_\_\_  
 LOGGED BY R. Foresti RANGE 200 BORE HOLE 102  
 DATE/TIME 1/8/88 DEPTH TO FLUID \_\_\_\_\_ PROBE TYPE \_\_\_\_\_



# GAMMA RAY LOG

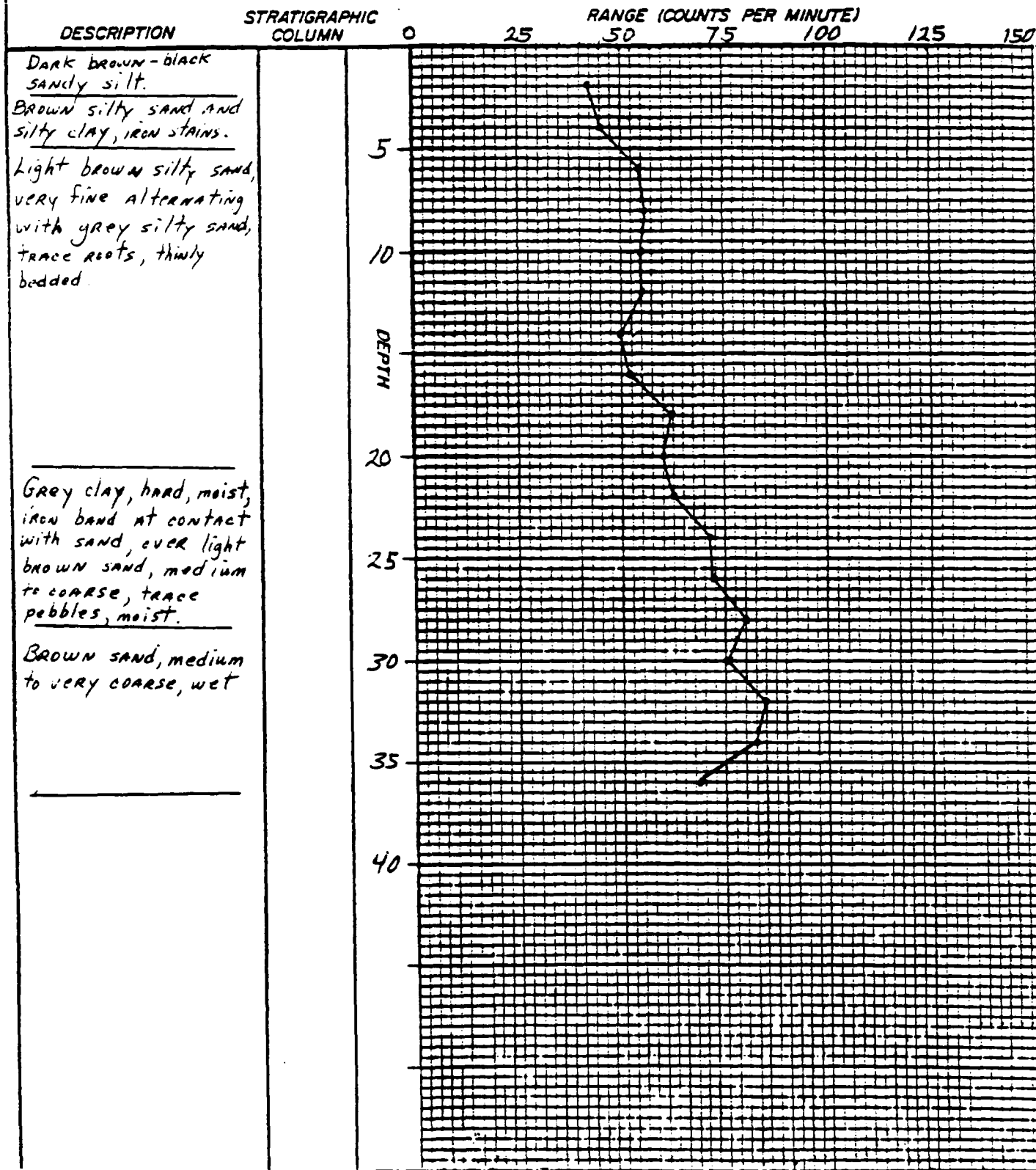
LOCATION N.L. Industries TIME CONSTANT 10 TYPE OF FLUID \_\_\_\_\_  
 LOGGED BY R. Foresti RANGE 200 BORE HOLE 104  
 DATE/TIME 1/8/87 DEPTH TO FLUID \_\_\_\_\_ PROBE TYPE \_\_\_\_\_



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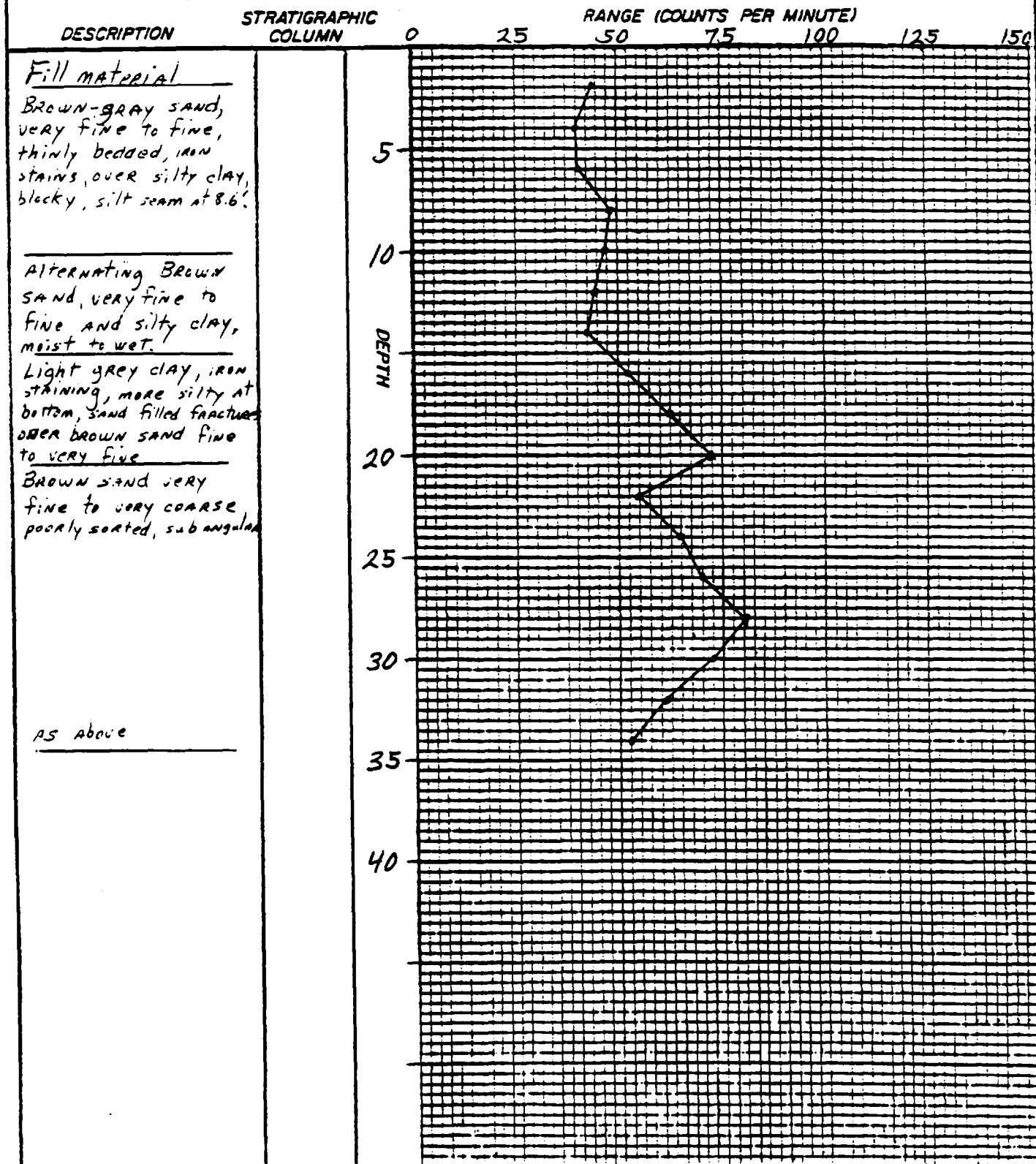
# GAMMA RAY LOG

LOCATION N-1 Industries TIME CONSTANT 10 TYPE OF FLUID \_\_\_\_\_  
 LOGGED BY R. Foresti RANGE 200 BORE HOLE 105-D  
 DATE/TIME 1/8/87 DEPTH TO FLUID \_\_\_\_\_ PROBE TYPE \_\_\_\_\_



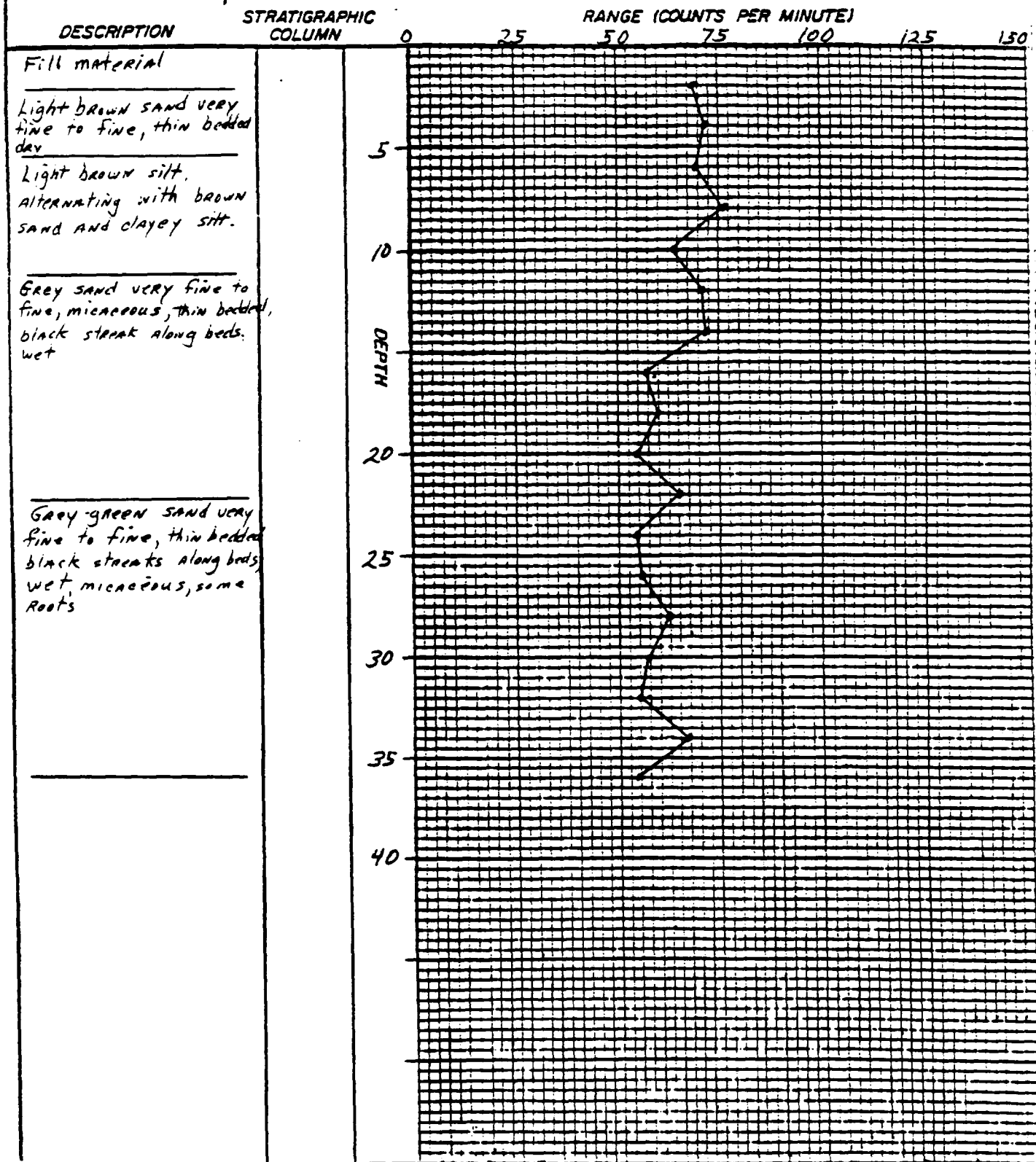
# GAMMA RAY LOG

LOCATION N-L Industries TIME CONSTANT 10 TYPE OF FLUID \_\_\_\_\_  
 LOGGED BY R. Foresti RANGE 200 BORE HOLE 106-D  
 DATE/TIME 1/8/87 DEPTH TO FLUID \_\_\_\_\_ PROBE TYPE \_\_\_\_\_



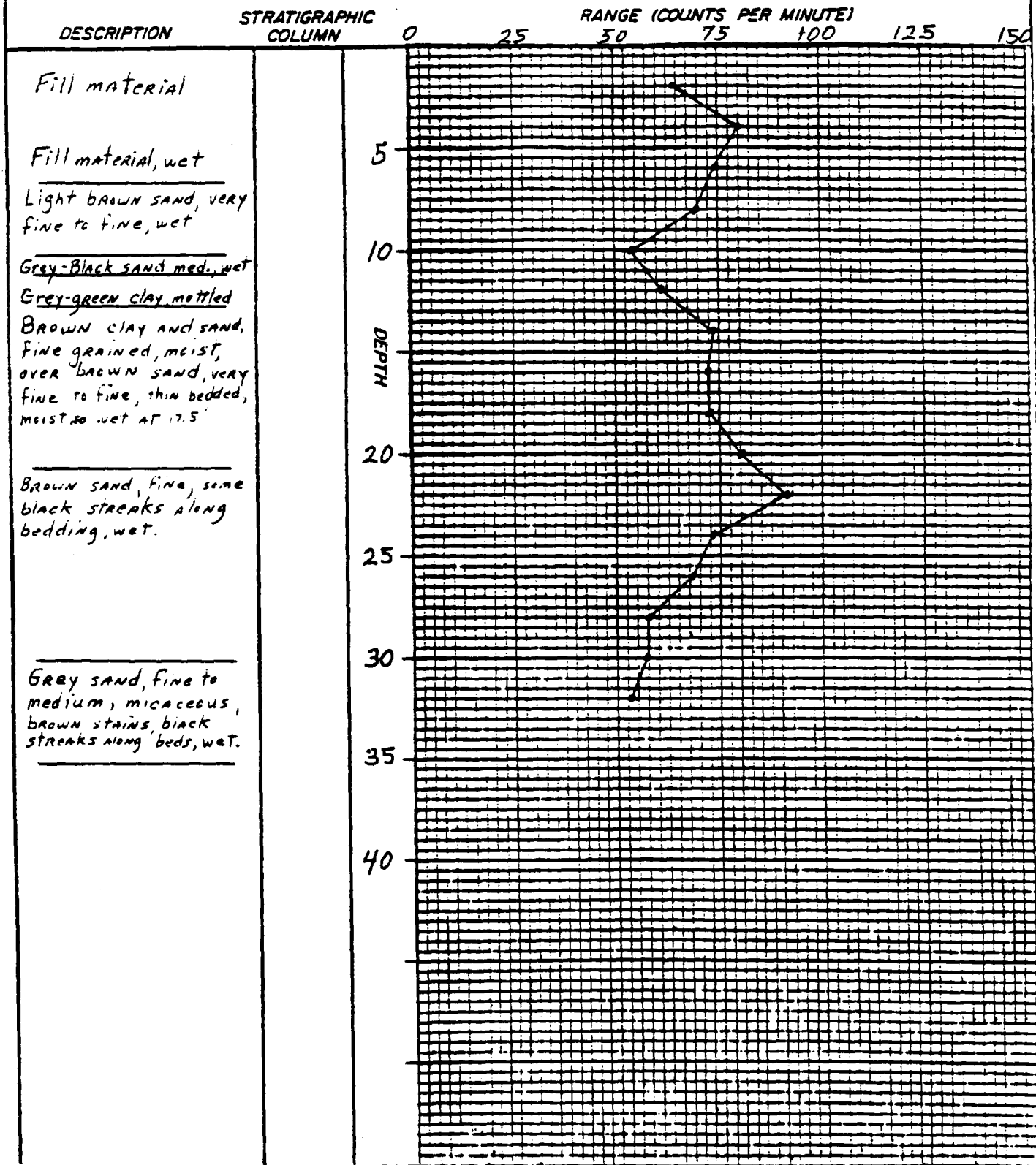
# GAMMA RAY LOG

LOCATION N-L Industries TIME CONSTANT 10 TYPE OF FLUID \_\_\_\_\_  
 LOGGED BY R. Foresti RANGE 200 BORE HOLE 107-D  
 DATE/TIME 1/8/87 DEPTH TO FLUID \_\_\_\_\_ PROBE TYPE \_\_\_\_\_



# GAMMA RAY LOG

LOCATION N-L Industries TIME CONSTANT 10 TYPE OF FLUID \_\_\_\_\_  
 LOGGED BY R. Foresti RANGE 200 BORE HOLE 108-D  
 DATE/TIME 1/8/87 DEPTH TO FLUID \_\_\_\_\_ PROBE TYPE \_\_\_\_\_

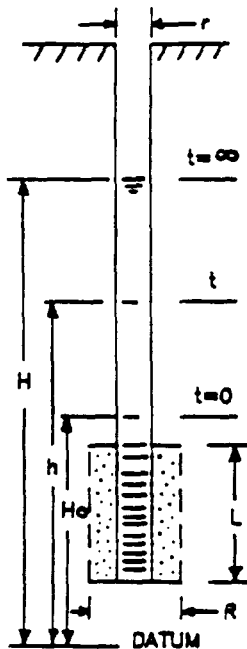


## APPENDIX C

# IN-SITU PERMEABILITY TEST FIELD LOG

PROJECT W-1 Sandstone  
WELL NUMBER 101  
DATE 1/8/87

LOCATION Granite City, IL  
ELEVATION \_\_\_\_\_



STATIC HEAD (H) 5.60 ft

PIPE RADIUS (r) .02

SCREEN RADIUS (R) .08

SCREEN LENGTH (L) 10

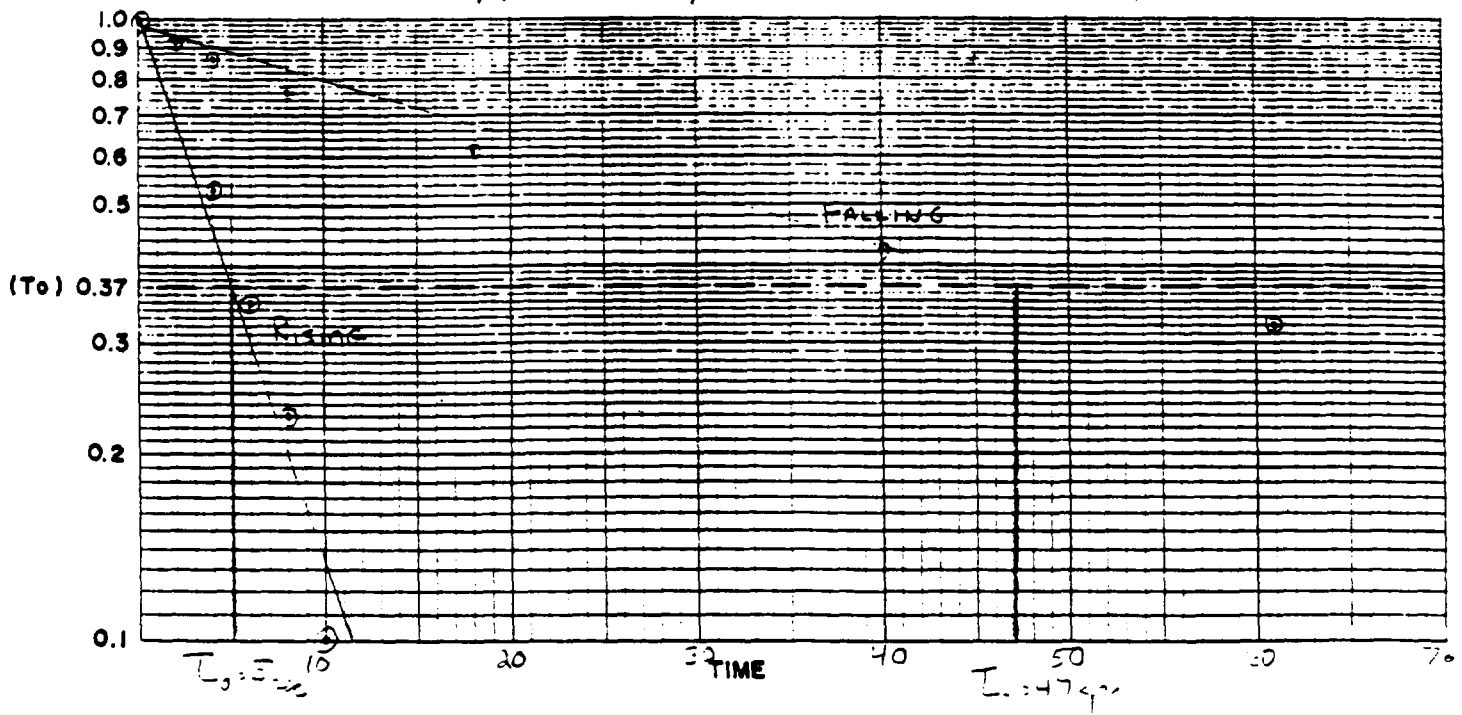
INITIAL HEAD (Ho) 5.60  
7.37

HYDRAULIC CONDUCTIVITY:

$$K = \frac{r^2 \ln(L/R)}{2LT_0}$$

$K = \frac{21.9 \text{ gpd/ft}^2 \text{ (falling)}}{9.9 \times 10^{-3} \text{ cm/sec}}$        $\frac{199.9 \text{ gpd/ft}^2 \text{ (rising)}}{9.4 \times 10^{-3} \text{ cm/sec}}$

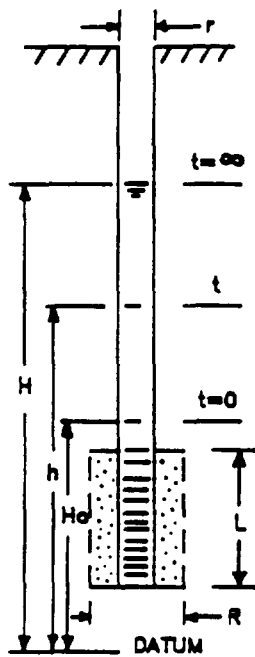
TIME	WATER DEPTH	t	h	H-h H-Ho
Rising	5.21	0	5.39	1.00
head	5.39	4	5.21	0.53
test	5.46	6	5.14	0.55
	5.51	8	5.07	0.57
	5.56	10	5.01	0.60
Falling	7.37	2	7.23	1.00
head	7.23	2	7.13	0.92
test	7.13	4	7.05	0.86
	6.95	8	6.95	0.76
	6.68	18	6.68	0.61
	6.35	40	6.35	0.42
	6.18	61	6.18	0.32



# IN-SITU PERMEABILITY TEST FIELD LOG

PROJECT N-L Industries  
WELL NUMBER 102  
DATE 1/8/87

LOCATION Granite City IL  
ELEVATION \_\_\_\_\_



STATIC HEAD (H) 8.03

PIPE RADIUS (r) 0.08

SCREEN RADIUS (R) 0.03

SCREEN LENGTH (L) 10

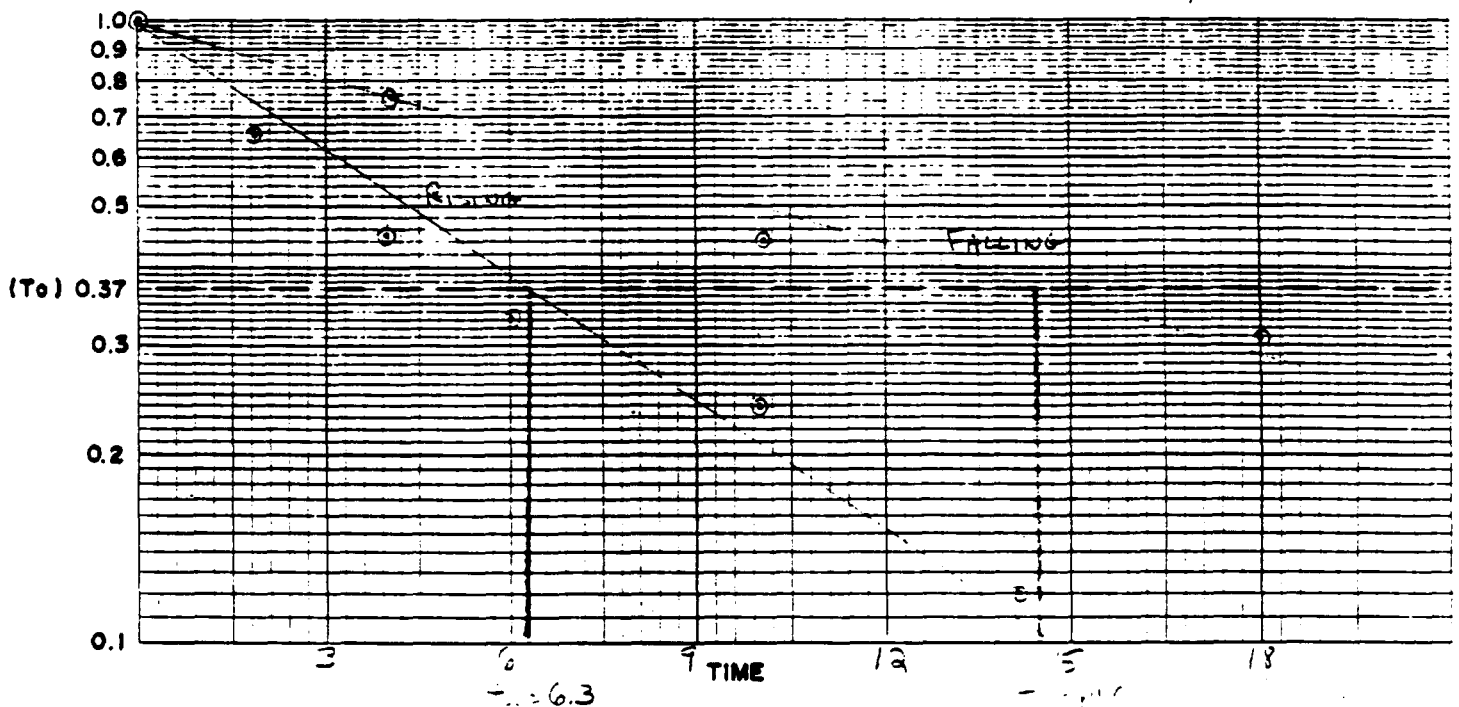
INITIAL HEAD (Ho) 6.62  
8.32

HYDRAULIC CONDUCTIVITY :

$$K = \frac{r^2 \ln(L/R)}{2LT_0}$$

K = 6.3 gpd/ft<sup>2</sup> (falling) 153 gpd/ft<sup>2</sup> (rising)  
 $3.3 \times 10^{-3}$  cm/sec.  $7.4 \times 10^{-3}$  cm/sec.

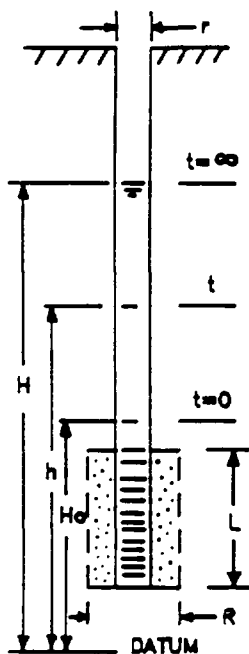
TIME	DEPTH	t	h	$\frac{H-h}{H-H_0}$
Rising	6.62	0	1.41	1.00
Head	7.09	2	0.94	0.66
Test	7.39	4	0.64	0.45
	7.56	6	0.47	0.33
	7.67	10	0.34	0.24
	7.86	14	0.17	0.12
	7.96	18	0.07	
Falling	7.32	0	0.29	1.00
Head	8.25	1	0.22	0.75
Test	8.16	10	0.13	0.44
	8.12	18	0.09	0.31
	8.08	34	0.05	0.17



# IN-SITU PERMEABILITY TEST FIELD LOG

PROJECT 11- Inactive  
WELL NUMBER 104  
DATE 1/8/87

LOCATION GRANITE CITY, IL  
ELEVATION \_\_\_\_\_



STATIC HEAD (H) 7.12 ft

PIPE RADIUS (r) 0.08

SCREEN RADIUS (R) 0.08

SCREEN LENGTH (L) 10.0

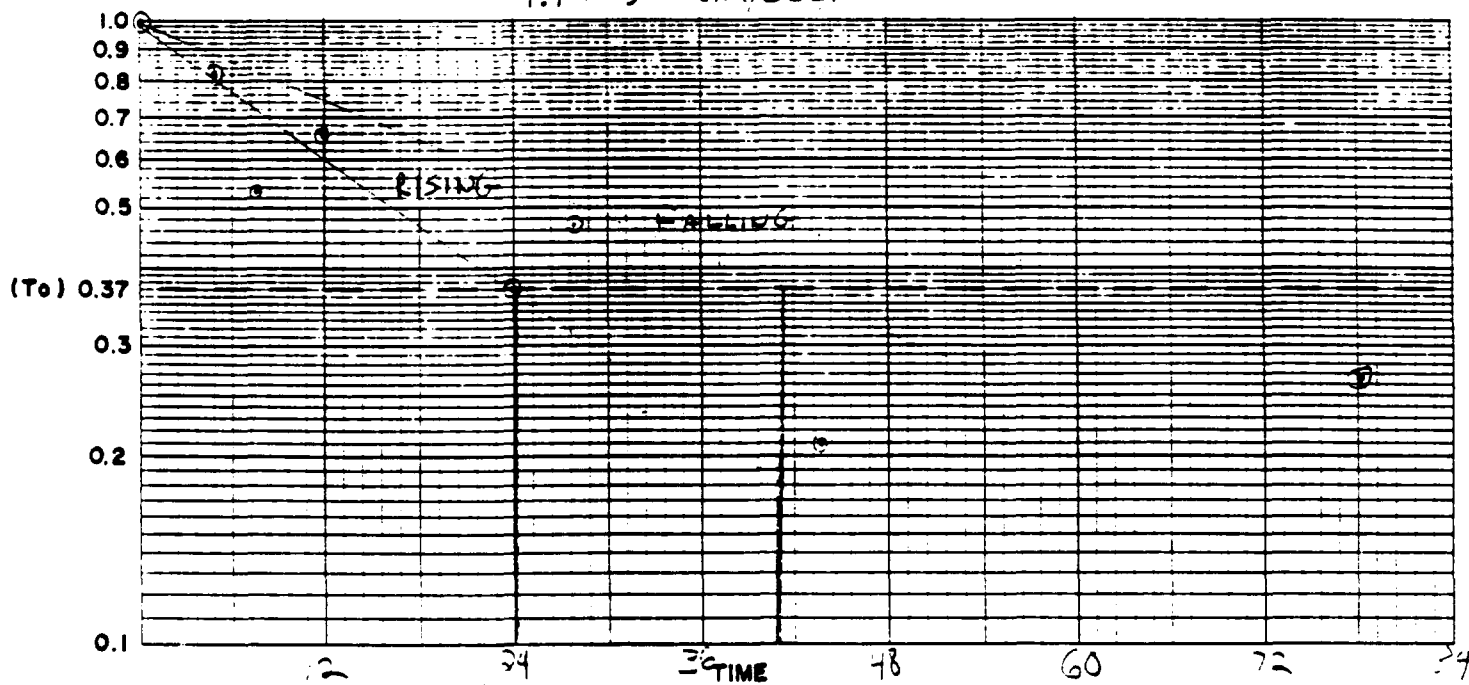
INITIAL HEAD (Ho) 6.55  
7.62

HYDRAULIC CONDUCTIVITY:

$$K = \frac{r^2 \ln(L/R)}{2LT_0}$$

$K = \underline{24.9 \text{ gpd/ft}^2} \text{ (falling)} \quad \underline{41.5 \text{ gpd/ft}^2} \text{ (rising)}$   
 $\underline{1.1 \times 10^{-4} \text{ cm/sec.}} \quad \underline{1.9 \times 10^{-3} \text{ cm/sec.}}$

TIME	DEPTH	t	h	$\frac{H-h}{H-H_0}$
Rising	6.80	0	7.32	1.00
Head	6.95	2	7.17	.53
Test	7.00	24	7.12	.37
	7.05	44	7.07	.21
	7.10	100	7.02	-
Falling	7.52	0	7.10	1.00
Head	7.44	-	7.32	0.30
Test	7.38	12	7.26	0.65
	7.31	28	7.19	0.47
	7.23	78	7.11	0.27
	7.18	152	7.06	-



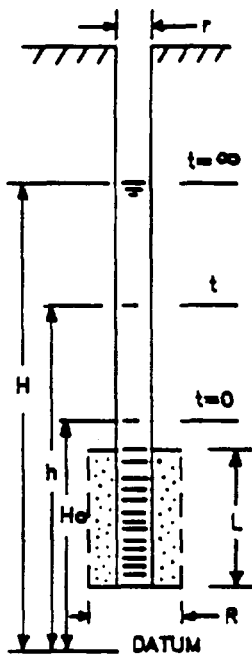


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# IN-SITU PERMEABILITY TEST FIELD LOG

PROJECT N-L INDUSTRIES  
WELL NUMBER 105-3  
DATE 1/8/87

LOCATION GRANITE CANYON  
ELEVATION                     



STATIC HEAD (H) 9.50 ft

PIPE RADIUS (r) 0.08

SCREEN RADIUS (R) 0.08

SCREEN LENGTH (L) 5.0

INITIAL HEAD (Ho) 8.28  
12.59

HYDRAULIC CONDUCTIVITY :

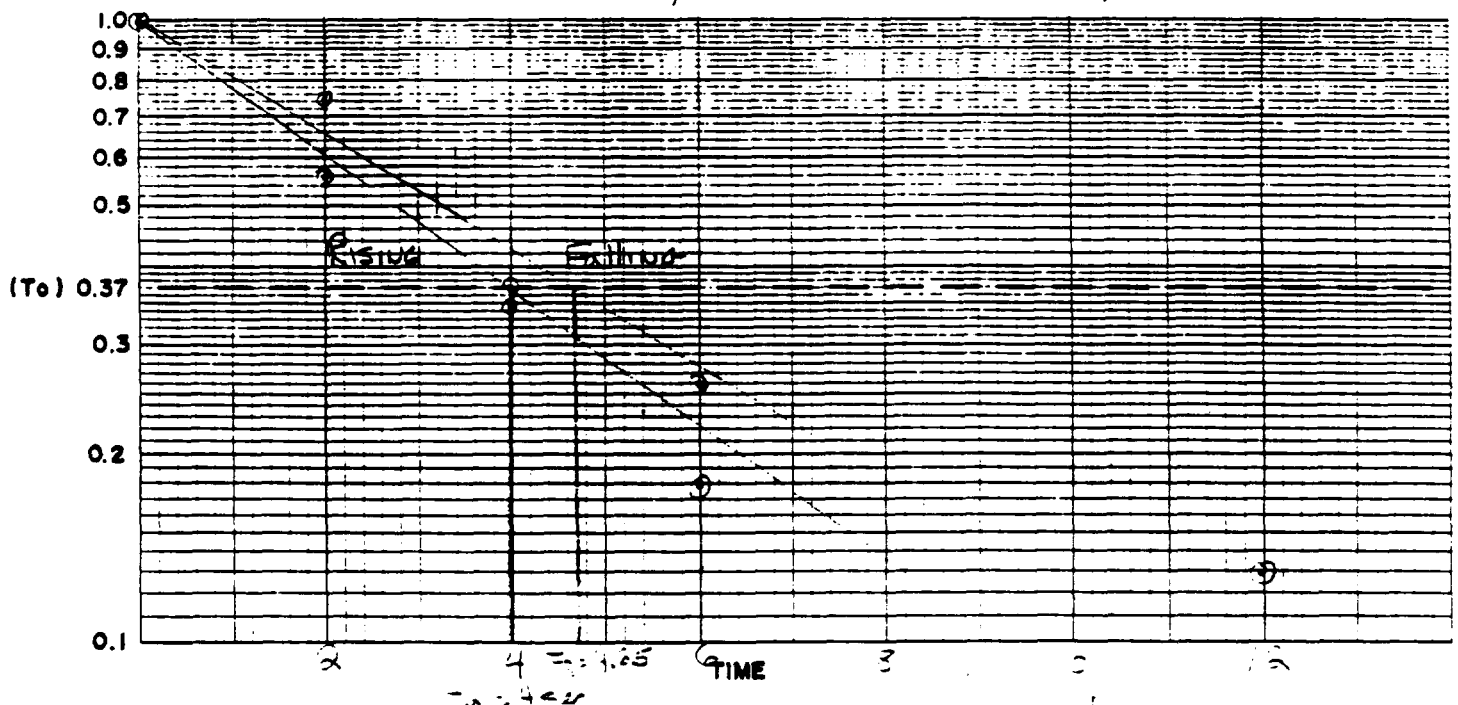
$$K = \frac{r^2 \ln(L/R)}{2LT_0}$$

$$K = \frac{424 \text{ gpd/ft}^2 \text{ (rising)}}{2 \times 10^{-2} \text{ cm/sec.}}$$

TIME	DEPTH	t	h	$\frac{H-h}{H-H_0}$
Rising	9.28	0	1.22	1.00
Head	8.52	2	0.98	0.75
Test	9.04	4	0.46	0.37
	9.28	6	0.22	0.17
	9.0	8	0.10	0.08
	9.45	10	0.05	
Falling	9.30	2	0.30	1.00
Head	9.67	4	0.17	0.50
Test	9.61	6	0.11	0.30
	9.58	8	0.08	0.20
	9.54	12		0.13

$$361.9 \text{ gpd/ft}^2 \text{ (falling)}$$

$$1.7 \times 10^{-2} \text{ cm/sec}$$

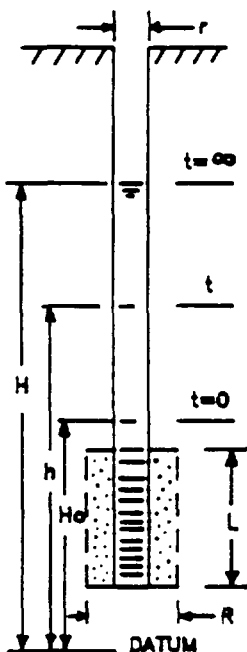




# IN-SITU PERMEABILITY TEST FIELD LOG

PROJECT N-L INDUSTRIES  
WELL NUMBER 107-S  
DATE 1/8/87

LOCATION GRANITE CITY IL  
ELEVATION \_\_\_\_\_



STATIC HEAD (H) 6.35ft

PIPE RADIUS (r) 0.08

SCREEN RADIUS (R) 0.08

SCREEN LENGTH (L) 5.0

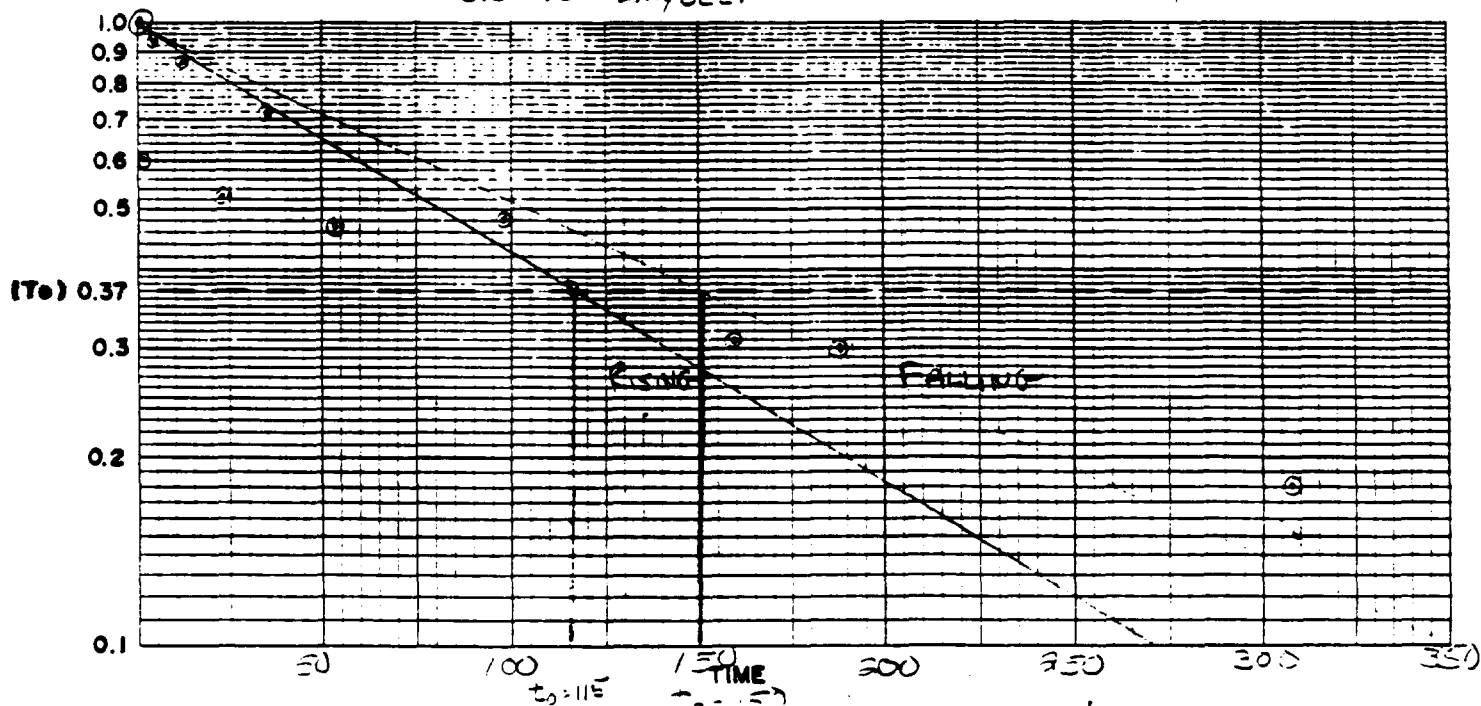
INITIAL HEAD (H<sub>0</sub>) 5.06

HYDRAULIC CONDUCTIVITY:

$$K = \frac{r^2 \ln(L/R)}{2LT_0}$$

$K = \frac{11.2 \text{ gpd/ft}^2 \text{ (falling)}}{5.3 \times 10^{-4} \text{ cm/sec.}}$        $\frac{14.6 \text{ gpd/ft}^2 \text{ (rising)}}{6.9 \times 10^{-4} \text{ cm/sec.}}$

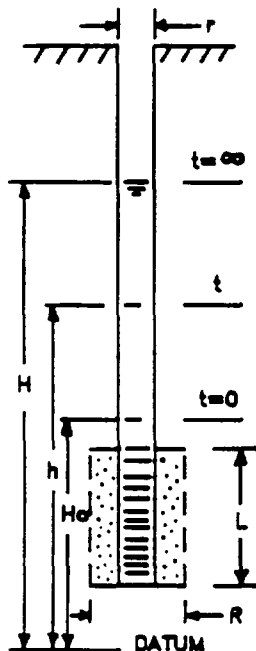
TIME	DEPTH	t	h	$\frac{H-h}{H-H_0}$
RISING	5.06	0	1.29	1.00
HEAD	5.54	2	0.21	0.62
TEST	5.66	24	0.21	0.53
	5.74	54	0.61	0.47
	5.86	114	0.49	0.37
	5.95	159	0.40	0.31
	6.15	307	0.20	0.15
FALLING	7.72	2	1.37	1.00
HEAD	7.65	4	1.30	0.94
TEST	7.55	12	1.30	0.87
	7.35	36	1.00	0.72
	7.03	97	0.68	0.49
	6.77	187	0.42	0.30
	6.60	307	0.25	0.18



# IN-SITU PERMEABILITY TEST FIELD LOG

PROJECT N-L INDUSTRIES  
WELL NUMBER 107-0  
DATE 1/8/87

LOCATION GRANITE CITY, IL.  
ELEVATION \_\_\_\_\_



STATIC HEAD (H) 10.12

PIPE RADIUS (r) 0.08

SCREEN RADIUS (R) 0.08

SCREEN LENGTH (L) 5.0

INITIAL HEAD (Ho) 7.91  
12.28

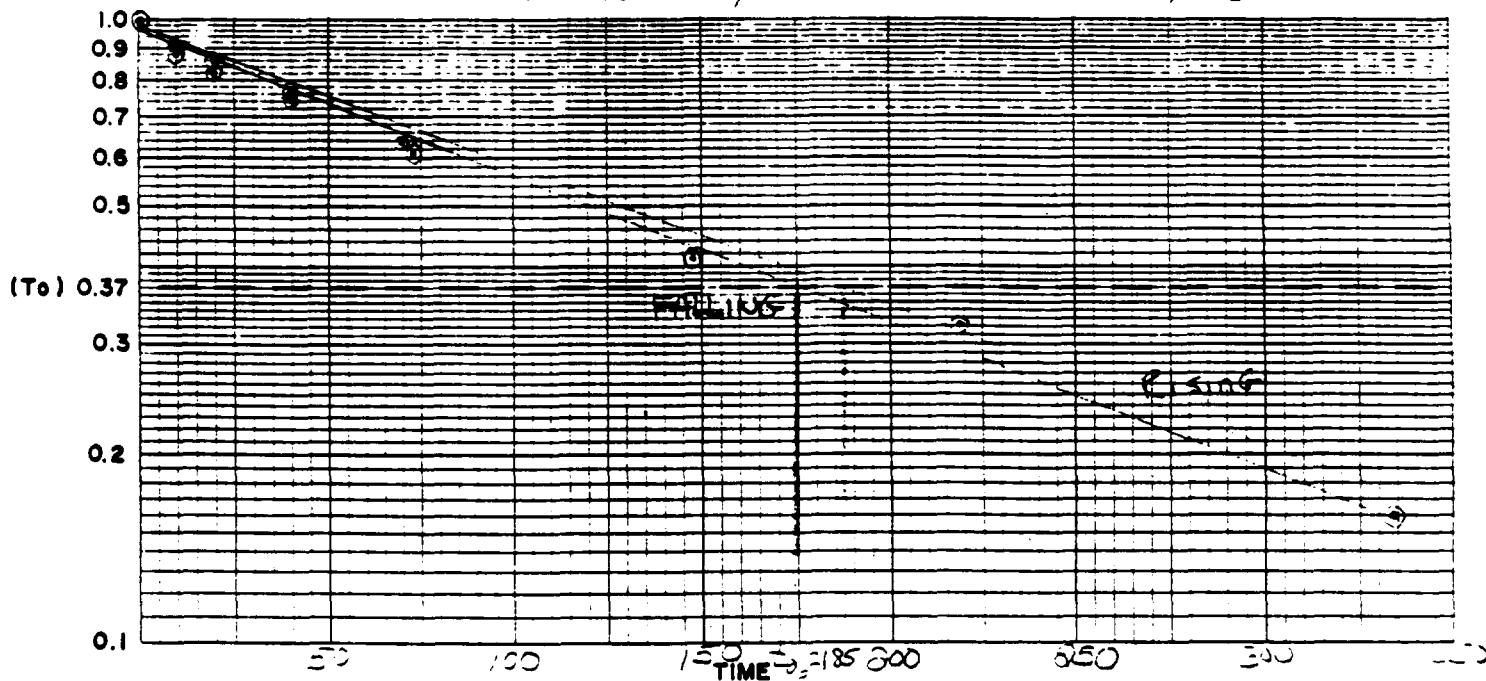
HYDRAULIC CONDUCTIVITY:

$$K = \frac{r^2 \ln(L/R)}{2LT_0}$$

$$K = \frac{9.1 \text{ gpd/ft}^2 \text{ (rising)}}{4.3 \times 10^{-4} \text{ cm/sec}}$$

$$K = \frac{9.6 \text{ gpd/ft}^2 \text{ (falling)}}{4.5 \times 10^{-4} \text{ cm/sec}}$$

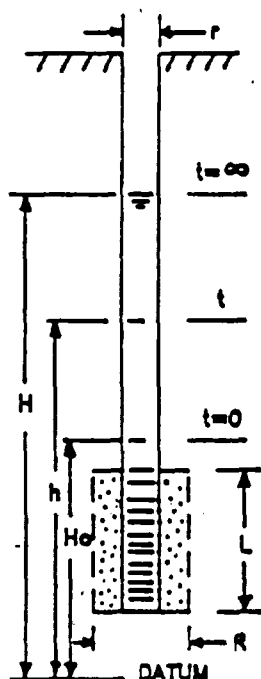
TIME	WATER DEPTH	t	h	H-h H-Ho
Rising	7.91	0	2.21	1.00
HEAD	2.16	10	1.96	0.22
TEST	2.29	20	1.83	0.22
	2.43	40	1.64	0.74
	2.71	69	1.41	0.63
	9.35	219	0.77	0.34
	9.67	369	0.43	0.19
FALLING	12.28	0	2.16	1.00
HEAD	12.07	10	1.95	0.90
TEST	11.96	20	1.84	0.35
	11.75	40	1.63	0.75
	11.44	74	1.32	0.61
	11.01	149	0.89	0.41
	10.48	329	0.36	0.16



# IN-SITU PERMEABILITY TEST FIELD LOG

PROJECT N-L INDUSTRIES  
WELL NUMBER 108-0  
DATE 11/8/87

LOCATION GRANITE CITY, IL.  
ELEVATION \_\_\_\_\_



STATIC HEAD (H) 11.37

PIPE RADIUS (r) 0.08

SCREEN RADIUS (R) 0.08

SCREEN LENGTH (L) 5.0

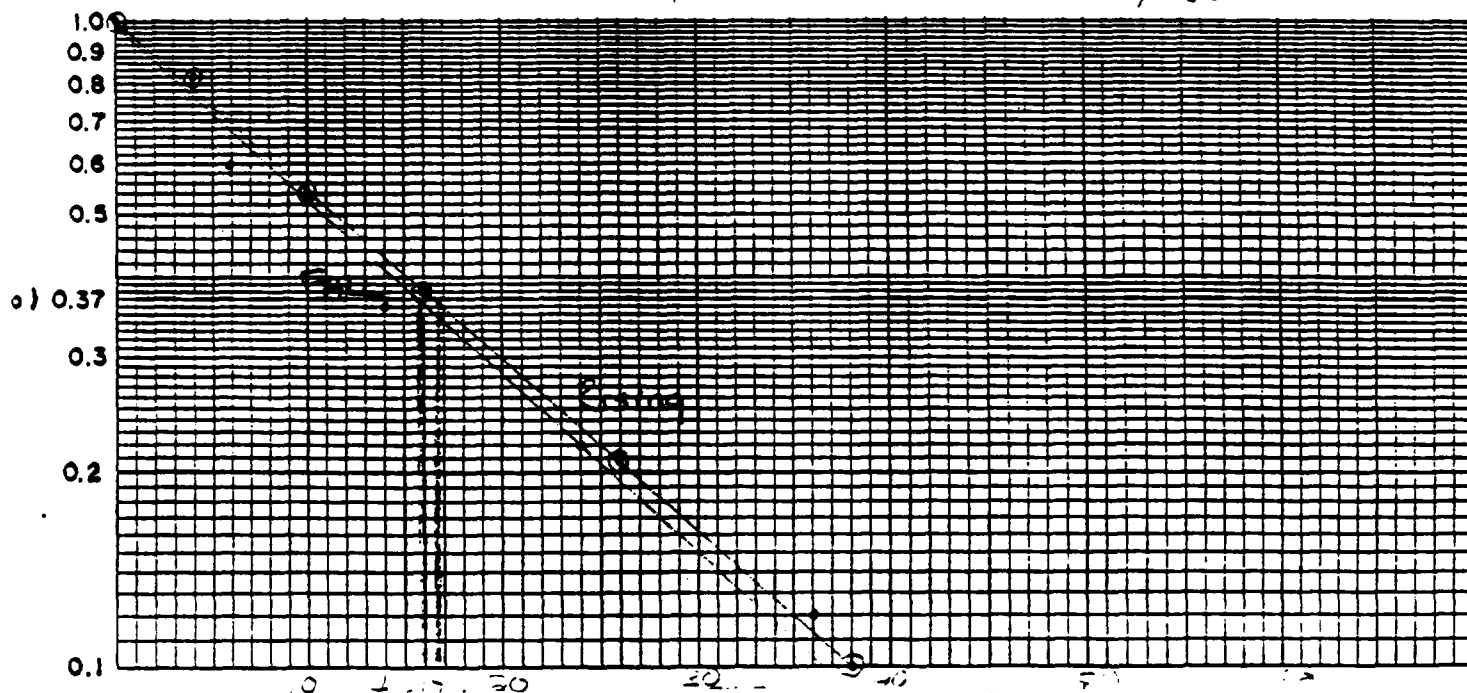
INITIAL HEAD (Ho) 9.08-R  
11.87-F

HYDRAULIC CONDUCTIVITY:

$$K = \frac{r^2 \ln(L/R)}{2LT_0}$$

$K = \frac{98.8 \text{ gpd/ft}^2 (\text{rising})}{4.7 \times 10^{-3} \text{ cm/sec.}}$   $\frac{105.9 \text{ gpd/ft}^2 (\text{falling})}{4.9 \times 10^{-3} \text{ cm/sec.}}$

WATER				
TIME	DEPTH	t	h	$\frac{H-h}{H-H_0}$
RISING	9.08	0	2.29	1.00
HEAD	9.48	4	1.89	0.32
TEST	10.12	10	1.25	0.54
	10.49	16	0.88	0.38
	10.87	26	0.50	0.21
	11.13	38	0.24	0.10
	11.28	52	0.09	0.03
FALLING	11.87	0	0.50	1.00
HEAD	11.67	2	0.30	0.60
TEST	11.55	14	0.18	0.36
	11.48	24	0.11	0.22
	11.43	36	0.06	0.12
	11.37	50		



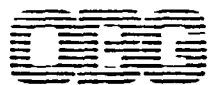
## APPENDIX D

## ANALYTICAL RESULTS - GROUND WATER

### KEY

<u>Description</u>	<u>Monitoring Well</u>
c101, 101 00, Min 101	101
c102, 102 00	102
103, 103 00	103
c104, 104 00	104
c105S	105S
c105D, 105 99	105D
106S	106S
C106D, 106 99	106D
C107S, 107 11	107S
C107D, 107 99, Min 1070	108S
C108S	108S
C108D, 108 99, Min 1080	108D
109, Min 109	109
110, Min 110	110

Note: A review of the analytical results for the ground water samples relative to the QA/QC objectives specified in the QAPP is presented in Appendix E.



LABORATORIES, INC.

Page 1

## Laboratory Report

CLIENT NL INDUSTRIES - Granite City

JOB NO. 2844.012.517

DESCRIPTION Wells

DATE COLLECTED 1-7,10,17-87

DATE REC'D 1-29-87

DATE ANALYZED

Description	C101 41010	C102 41020	103 41030	C104 41040	C1055 41051	C105D 41059	1065 41061	C106D 41069	C1075 41071	C107D 41079	C1085 41081	C108D 41089
Sample #	D3901	D3903	D3915	D3907	D3909	D3911	D3913	D3915	D3917	D3919	D3921	D3923
LEAD, FILTERED	0.009	0.013	<0.005	<0.005	<0.005	<0.005	<0.005	0.011	<0.005	<0.005	0.005	0.006
BARIUM, FILTERED	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.	<1.
SELENIUM, FILTERED	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.05
COPPER, FILTERED	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
NICKEL, FILTERED	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.20	0.50
CADMIUM, FILTERED	<0.001	<0.001	<0.00	0.002	0.002	0.006	0.013	0.008	0.001	<0.001	0.209	3.3
ARSENIC, FILTERED	0.077	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	<0.005	0.011	<0.005	0.007
SILVER, FILTERED	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
IRON, FILTERED	20.	0.12	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	7.7	<0.10	<0.10
ZINC, FILTERED	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	0.27	0.09	<0.02	*	0.04	37.
CHROMIUM, FILTERED	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
MERCURY, FILTERED	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
ANTIMONY, FILTERED	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
MANGANESE, FILTERED	4.3	0.27	0.06	0.03	<0.025	0.19	0.08	0.09	0.07	0.43	13.1	10.1

Methodology: Federal Register — 40 CFR, Part 136, October 26, 1984

Units: mg/l (ppm) unless otherwise noted

Comments: \*No Sample Remaining

OHS Laboratories, Inc.  
Box 4942 / 1304 Buckley Rd / Syracuse, NY 13221 / (315) 457-1771

Authorized

Date

*DH Borden*  
May 14, 1987



# Laboratory Report

CLIENT NL - TARACORP

JOB NO. 2344.012.517

DESCRIPTION \_\_\_\_\_

DATE COLLECTED 8-12-87

DATE REC'D. 8-14-87

DATE ANALYZED \_\_\_\_\_

Description		107D	108D	101	110	109	109 Duplicate
Sample #		G0204	G0205	G0206	G0207	G0208	G0209
TOTAL DISSOLVED SOLIDS		1300.	4600.	650.	1000.	530.	530.
SULFATE		490.	1800.	160.	280.	78.	75.
LEAD	Filtered	<0.005	0.009	<0.005	<0.005	<0.005	<0.005
CADMIUM	Filtered	<0.001	6.9	0.007	0.004	<0.001	<0.001
ARSENIC	Filtered	<0.005	0.007	0.101	<0.005	<0.005	0.006
IRON	Filtered	6.6	<0.10	22.	<0.10	<0.10	<0.10
MANGANESE	Filtered	0.40	25.	4.9	1.0	0.11	0.10
NICKEL	Filtered	<0.01	0.94	<0.01	0.02	<0.01	<0.01
ZINC	Filtered	<0.02	44.	0.10	0.02	<0.02	<0.02
CHROMIUM	Filtered	-	-	-	<0.005	<0.005	<0.005
BARIUM	Filtered	-	-	-	<1.	<1.	<1.
MERCURY	Filtered	-	-	-	<0.0002	<0.0002	<0.0002
SELENIUM	Filtered	-	-	-	<0.002	<0.002	<0.002
SILVER	Filtered	-	-	-	<0.005	<0.005	<0.005
ANTIMONY	Filtered	-	-	-	<0.02	<0.02	<0.02
COPPER	Filtered	-	-	-	<0.01	0.01	<0.01
LEAD		-	-	-	0.016	0.007	<0.005

Methodology: Federal Register — 40 CFR, Part 136, October 26, 1984

Units: mg/L (ppm) unless otherwise noted

Comments:

OBG Laboratories, Inc.  
Box 4942 / 1304 Buckley Rd. / Syracuse, NY / 13221 / (315) 457-1494

Authorized: \_\_\_\_\_

Date: October 6, 1987



# Laboratory Report

CLIENT NL - Granite City

JOB NO. 2844.012.517

DESCRIPTION \_\_\_\_\_

DATE COLLECTED 11-12-87

DATE REC'D. 11-13-87

DATE ANALYZED \_\_\_\_\_

Description	MW101	MW110	MW109	MW1070	MW1080	MW1070 Duplicate	MW110 Duplicate
Sample #	G2723	B2724	G2725	G2726	G2727	G2728	G2729
SULFATE	170.	294.	68.	480.	1825.	474.	289.
TOTAL DISS. SOLIDS	690.	1000.	500.	1232.	4400.	1248.	980.
LEAD, FILTERED	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CADMIUM, FILTERED	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ARSENIC, FILTERED	0.071	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
IRON, FILTERED	22.	<0.10	0.4	5.8	<0.10	5.5	<0.10
MANGANESE, FILTERED	0.05	0.09	0.07	0.05	0.05	0.05	0.098
NICKEL, FILTERED	<0.01	0.01	<0.01	<0.01	0.81	<0.01	0.01
ZINC, FILTERED	0.02	<0.02	<0.02	<0.02	44.	<0.02	<0.02
BARIUM, FILTERED	-	<1.	<1.	-	-	-	<1.
CHROMIUM, FILTERED	-	<0.005	<0.005	-	-	-	<0.005
SELENIUM, FILTERED	-	<0.002	<0.002	-	-	-	<0.002
SILVER, FILTERED	-	<0.005	<0.005	-	-	-	<0.005
ANTIMONY, FILTERED	-	<0.02	<0.02	-	-	-	<0.02
COPPER, FILTERED	-	<0.01	<0.01	-	-	-	<0.01
MERCURY, FILTERED	-	<0.0002	<0.0002	-	-	-	<0.0002
LEAD	-	<0.005	<0.005	-	-	-	<0.005

Methodology: Federal Register — 40 CFR, Part 136, October 26, 1984

Units: mg/l (ppm) unless otherwise noted

Comments:

OBG Laboratories, Inc.  
Box 4942 / 1304 Buckley Rd. / Syracuse, NY / 13221 / (315) 457-1494

Authorized: D.A. Brundage

Date: December 10, 1987

## APPENDIX E

QA/QC REVIEW OF ANALYTICAL RESULTS GENERATED DURING THE GRANITE CITY SITE RI

Introduction

The Remedial Investigation (RI) conducted at the Granite City Site in Granite City, Illinois included the sampling and analysis of several environmental matrices, including soils, sediments, ground water, surface water, and materials comprising the waste piles. The analytical program is presented as Table 4 of the RI Report.

The Quality Assurance Project Plan (QAPP) for the Granite City RI/FS included quality assurance objectives for measurement data in terms of precision, accuracy and completeness for the various matrices analyzed. In addition, quality control objectives were intended to be consistent with those established for the USEPA's Contract Laboratory Program (CLP) for inorganics. The data have been reviewed in accordance with the QA/QC objectives set forth in the QAPP.

In addition, the data have been reviewed relative to the overall objectives of the project, which were matrix specific. The analytical results for the slag pile and soil samples were for characterization purposes as there are neither state nor federal standards for slag or soils. The data generated for the slag pile were intended to determine whether the materials in the pile are hazardous or non-hazardous, if the constituents are mobile (soluble), and if metal concentrations are sufficient to warrant recycling of the materials. In other words, the data for the slag pile were intended to be used to evaluate management alternatives for the slag pile. Management of the pile is intimately related to the lead concentration in the pile, since lead would be

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reiterated that the slag and soil samples were analyzed for characterization purposes and that no state or federal standards exist for these materials.

1. The initial calibration verification (ICV) for mercury analyzed on March 13, 1987 was 78%, which is less than the lower acceptance limit of 90%. The ICV concentration was close to the lower sensitivity of the procedure, where precision is highly variable. The other concentrations on the calibration curves were all within the acceptance range. The raw data from the mercury injection logbook indicate that mercury was detected, but at concentrations near or below the instrument detection limit of 0.5 ppb. In terms of the overall project objectives for the slag pile, the data are usable. Adjustments to the data to correct for the ICV do not significantly change the results.
2. The continuous calibration verification (CCV) for mercury on March 13, 1987, at 130%, was above the upper acceptance limit of 110%. The CCV concentration here was also close to the lower sensitivity of the procedure, where precision is in question. However, the data reported after this CCV was analyzed, with one exception, were all below the instrument's detection limit. Accordingly, the data are usable.
3. The CCV for selenium on March 23, 1987 and April 24, 1987 were below the lower acceptance limit of 90%. The CCV's on March 23, 1987 were 82.5% and 64%. The analytical data associated with the CCV's were all less than the detection

limit of the instrument. Adjusting the data for the low CCV's does not change the data relative to the project's objectives and the data are usable. The CCV for selenium on April 24, 1987 was 71%. In this case, the CCV concentration was less than the instrument detection limit. All reported data associated with the CCV had concentrations less than the detection limit. Adjustments of the data do not change the results relative to the overall project objectives. These data are usable.

4. The spike recovery for copper on March 18, 1987 was 42%, compared to the range of  $100\% \pm 25\%$  specified by the QAPP. Spikes are used to determine the accuracy of the analytical method. The nature of the material making up the slag pile is such that one could not expect the analytical results to be highly accurate. The results are usable since they are intended to be used in characterizing the slag pile materials.
5. The spike recoveries for zinc analyzed on April 6, 1987 were 2.2% and 140%, which are outside the range specified in the QAPP of  $100\% \pm 25\%$ . These recoveries reflect the variability of the slag pile material. All other QC data are within the specified guidelines. The data are usable in that they are intended to be used for characterization purposes only.
6. The spike recovery for selenium on March 23, 1987 was 0%. There were matrix problems with the spike sample. The other QC samples analyzed along with the spike met or were just outside of the QAPP requirements. Since the data are intended for characterization purposes, the data are usable.

7. The spike recovery for selenium in the EP Toxicity sample on April 24, 1987 was 71%, which is just outside of the range specified in the QAPP. The EP Toxic concentration for selenium is 1 mg/l. The analytical results indicate the selenium concentration in the extract was less than the detection limit of 0.02 mg/l. Adjusting these data based on the spike recovery results in the same conclusion, that the samples did not exhibit the hazardous characteristic of EP Toxicity based on selenium.
8. The spike recovery for selenium in the slag sample analyzed on April 24, 1987 was 48%. As indicated in Item 6 above, matrix effects were a primary concern in the spike recovery for selenium. The data are usable based on the overall objective to use the data for characterization purposes.
9. The spike recovery for barium on April 13, 1987 was 48%. The other QC data associated with this spike sample met the requirements of the QAPP. Once again, the accuracy of the analysis was impacted by the matrix. The data are usable for characterization purposes.
10. No spike sample for antimony in slag was analyzed since the analytical results indicated the antimony concentration was four times greater than the spiking level. This being the case, the sample should have been analyzed in duplicate and the relative percent difference (RPD) reported. The EPA known and ICV analyses met the requirements of the QAPP, and the CCV was just outside the range specified by CLP. The data are usable for characterization purposes.

11. The duplicate samples for copper on March 18, 1987 had a RPD of 35% which is not within the acceptance limits. The data are usable for characterization purposes.
12. The laboratory control sample (LCS) for barium on April 13, 1987 was 130% which is out of the acceptable range of  $100\% \pm 10\%$ . The LCS concentration was close to the detection limit where precision is poor. The elevated LCS concentration observed would imply that the analytical results were also elevated. As the absolute concentration of barium in the slag samples is not critical to the objectives of the project, the data are usable.
13. The LCS for selenium on April 24, 1987 was 70.8%. The samples associated with this LCS were slag samples analyzed for EP Toxicity. The observed sample results were all less than the detection limit of 0.02 mg/l. Adjusting the sample results due to the depressed LCS result does not change the conclusion that the samples do not exhibit EP Toxicity for selenium.

To summarize the QA/QC review of the slag and soil analyses, although not all the QA/QC objectives were met, all the data are usable in terms of the overall objectives of the project.

#### Sediment

Four sediment samples representing surface runoff sediment from the slag pile were analyzed for lead. The sediment samples were intended to determine whether stormwater runoff from the slag pile is a mode of lead transport. All QA/QC objectives were met with the excep-

tion of the spike sample recovery. No spike was analyzed since the sample concentration exceeded the spiking level by a factor greater than or equal to four. All the data are usable relative to the overall objectives of the project.

#### Surface Water

Four surface water samples representing storm water runoff from the slag pile were analyzed for lead. The surface water samples were intended to determine whether storm water transports lead from the slag pile. All QA/QC objectives were met and the data are usable in terms of the overall project objectives.

#### Ground Water Analysis - Round 1

Twelve ground water samples were analyzed for 16 parameters and three additional samples were analyzed for total lead, resulting in a total of 195 analyses. The review of the QA/QC analyses for the ground water samples indicated that the QA/QC objectives were met in most cases. In those cases where certain QA/QC objectives were not attained, the corresponding sample results were determined to be usable relative to the overall objectives of the project. Those specific instances where discrepancies in the QA/QC samples were identified are discussed below:

1. The CCV for antimony analyzed on March 2, 1987 was 87.5% which was just outside the acceptance range of  $100\% \pm 10\%$ . All the sample results associated with this CCV were less than the detection limit of 20 ppb. The data are usable.

2. The ICV for arsenic analyzed on February 23, 1987 was below the acceptance range. The ICV was 86.5% which was just below the lower acceptance limit of 90%. All but one of the samples associated with this ICV were at or below the detection limit of 5 ppb. The sample that was above the detection limit had a concentration of 11 ppb. The applicable standard for arsenic (State of Illinois Public and Food Processing Water Supply Standards) is 50 ppb. Adjusting the data to reflect the low ICV does not change the conclusions based on the applicable standard. Accordingly, the data associated with this ICV are usable.
3. The CCV for arsenic analyzed on March 23, 1987 was 86%, just below the lower acceptance limit of 90%. The discussion presented in item 2 above holds true for this case. The data associated with this CCV are usable.
4. The CCV for arsenic analyzed on February 24, 1987 was 121%, which was above the upper acceptance limit of 110%. Three of the four samples associated with the CCV were below or just above the detection limit, whereas the other was above the detection limit and above the applicable standard for arsenic of 50 ppb. Adjusting the sample results for the elevated CCV does not change the conclusions relative to the applicable standard. The two samples that are below the detection limit remain below the detection limit. The sample that is just above the detection limit remains just above the detection limit. The sample whose concentration was above the applicable standard remains above the standard. The data associated with this CCV are usable.

5. The CCV for cadmium analyzed on March 5, 1987 was 80.7%, which was below the lower acceptance limit of 90%. All of the sample results associated with this CCV were at, below, or just above the detection limit which was 1 ppb. The applicable standard for cadmium (State of Illinois Public and Food Processing Water Supply Standards) is 10 ppb. Adjusting the data for the CCV results in all data still being below the applicable standard and does not change the conclusions relative to the applicable standard. The sample results associated with the CCV are usable.
6. The CCV's for chromium analyzed on March 4, 1987 were below the lower acceptance limit of 90%. The CCV's were 78.5% and 84.5%. The sample results for chromium were all less than the detection limit of 5 ppb. The applicable standard for chromium (State of Illinois Public and Food Processing Water Supply Standards) is 50 ppb. The conclusions do not change relative to the detection limit and applicable standard when adjusted for the CCV's. The sample results associated with the CCV's are usable.
7. The CCV's for copper analyzed on March 4, 1987 were 125% and 122%, which were above the upper acceptance limit of 100%. All the sample results for copper were below the detection limit of 10 ppb, with one exception. Once sample was analyzed at 20 ppb copper, which is the applicable standard (State of Illinois General use Water Quality Standards) for copper. Adjustment of the data based on the elevated CCV's would not affect the less than detectable

results. The sample result which was at the applicable standard would be less than the standard if adjusted for the CCV. The conclusions do not change since all samples meet the water quality standard for copper. The sample results are usable.

8. The CCV for lead analyzed on February 27, 1987 was above the upper acceptance limit of 110%. The CCV was 128%. Three samples for the NL Granite City project were associated with this CCV. One result was below the detection limit of 5 ppb, one was at the detection limit, and one was just above the detection limit (6 ppb). The applicable water quality standard for lead is 50 ppb (State of Illinois Public and Food Processing Water Supply Standards). Adjusting the sample results based on the elevated CCV would result in all three being below the detection limit. The adjustment would not affect the conclusions relative to the applicable water quality standard. These data are usable.
9. The CCV's for nickel analyzed on March 4, 1987 were 70.8% and 75.6%, which were below the lower acceptance level of 90%. Ten of the twelve samples analyzed were below the detection limit of 10 ppb. The two results above the detection limit were 20 ppb and 50 ppb. The applicable standard for nickel is 1,000 ppb (State of Illinois General Use Water Quality Standards). Adjusting the sample results based on the CCV's does not change the conclusions with respect to the applicable standard. The sample results are usable.

10. The CCV's for selenium analyzed on February 26, 1987 were below the lower acceptance limit of 90%. The CCV's were 78% and 83%. All the sample results were less than the detection limit of 2 ppb. The applicable standard for selenium is 10 ppb (State of Illinois Public and Food Processing Water Supply Standards). Adjusting the sample results based on the CCV's does not change the conclusions drawn from the data relative to the applicable standard. Accordingly, the data are usable.
11. Iron analyses were conducted on February 19, 1987 with no preparation blank analyzed. The sample preparation step consisted of filtration. The sample results indicated that ten of the twelve samples were below or just above the detection limit of 10 ppb. The sample results appear to be in control. The conclusions drawn from the data do not change due to the lack of preparation blank.
12. One of the spike samples for lead analyzed on February 27, 1987 was below the lower acceptance limit of 85%. The spike recovery was 69.5%. Three sample results were associated with this spike. One sample result was less than detectable, one was at the detection limit (5 ppb) and one was just above the detection limit (6 ppb). The applicable standard for lead is 50 ppb. The sample results were an order of magnitude less than the standard. The conclusions drawn from the data do not change upon consideration of the unacceptable spike recovery. The data are usable.

13. The spike sample recoveries for antimony analyzed on March 2, 1987 were below the lower acceptance level of 85%. The spike recoveries were 81.2% and 79.6%. All the sample results were less than the detection limit of 20 ppb. There is no state or federal standard for antimony. The conclusions drawn from the data do not change even though the spike recoveries were lower than the acceptable range. The data are usable.
14. The spike sample recovery for arsenic analyzed on February 24, 1987 was 117% which was just above the acceptance limit of 115%. Three sample results were associated with this spike. Two were less than the detection limit of 5 ppb and one (77 ppb) was greater than the applicable standard of 50 ppb. The conclusions based on the data do not change upon consideration of the spike recovery. Accordingly, the data are usable.
15. The spike recovery for cadmium analyzed on March 6, 1987 was 78.4%, which was below the lower acceptance limit of 85%. Two of the five sample results associated with this spike recovery were an order of magnitude less than the applicable standard for cadmium of 10 ppb. The other three were above the applicable standard. The conclusions drawn from these data do not change upon consideration of the spike sample. The data are usable.
16. The spike recovery for copper analyzed on March 4, 1987 was 117%, which was just above the upper limit of 115%. All the sample results associated with this spike samples were less

than the detection limit of 10 ppb. The conclusions drawn from the data do not change upon consideration of the elevated spike recovery. The data are usable.

17. Two spike sample recoveries for mercury analyzed on February 23, 1987 were just outside the acceptable range of  $100\% \pm 15\%$ . The spike recoveries were 83% and 120%. The sample results associated with these were all less than the detection limit of 0.5 ppb. The conclusions drawn from the data do not change upon consideration of the spike recoveries, and the data are usable.
18. A spike sample recovery for selenium analyzed on February 26, 1987 was below the lower acceptance limit of 85%. The spike recovery was 69%. The sample results of selenium were all less than the detection level of 5 ppb, which is compared to the applicable standard of 10 ppb. The conclusions drawn from the data do not change upon consideration of the spike sample recovery. The data are usable.
19. The spike sample recoveries for silver analyzed on March 5, 1987 were 81% and 75%, which were below the lower acceptance limit of 85%. All the sample results associated with these spikes were less than the detection limit of 5ppb. The state standard for silver is 5 ppb (State of Illinois General Use Water Quality Standards). The federal primary drinking water standard are not changed upon consideration of the spike recoveries. Conclusions based on the data are usable.
20. No LCS for iron was analyzed on February 19, 1987. The LCS would have provided information relative to the accuracy

of the results. The internal QC results were all well within the acceptable ranges. Ten of the twelve sample results were below or just above the detection limit of 10 ppb. The applicable standard for iron is 300 ppb. The other two sample results were well above the applicable standard. Considering that all the the internal QC for iron was excellent and the sample results were either at or below the detection limit, or well above the applicable standard, the lack of LCS does not change the conclusions drawn from the data. The data are usable.

21. Raw data for total dissolved solids and sulfate analyses were included with the QAPP data package. However, the laboratory work sheets were inadvertently left out of the data package. The laboratory work sheets for these analyses are attached. The QA/QC data for the sulfate analyses indicate that the QA/QC objectives were met for sulfate. QA/QC analyses for total dissolved solids were not reported. It should be noted that total dissolved solids were analyzed as an indicator parameter only.

In summary, all the Round 1 ground water data are usable, although several discrepancies in meeting the QA/QC objectives were identified. The data are of sufficient quality to meet the overall objectives for their use in this project.

## Ground Water Analysis - Round 2

Nine ground water samples were analyzed for 16 parameters and three additional samples were analyzed for total lead, resulting in a total of 147 analyses. The review of the QA/QC analyses for the ground water samples collected during the second round of sampling indicated that the QA/QC objectives specified in the QAPP were attained in most cases. In those instances where certain QA/QC objectives were not met, the associated sample results were determined to be usable in terms of the overall project objectives. Those specific instances where the QA/QC objectives were not attained are presented below.

1. The LCS for total lead analyzed on May 14, 1987 was 81%, which was just below the lower acceptance limit of 85%. The depressed LCS result suggests that the observed analytical results were also less than the actual concentrations. The three analytical results, 220, 280, and 720 ppb were all an order of magnitude greater than the applicable standard for drinking water for lead of 50 ppb. Adjusting the sample results based on the LCS would not change the conclusions relative to the drinking water standard for lead if it were an applicable standard. The sample results are usable.
2. No preparation blank for total lead was analyzed on May 14, 1987. All three samples analyzed exhibited lead concentrations an order of magnitude greater than the drinking water standard. With the exception of the LCS excursion discussed in item 1 above, all the QA/QC objectives were attained. The data appear to be in control and are usable.

3. The total lead analyses conducted on May 14, 1987 were analyzed by Method 239.1 (flame). While this is acceptable pursuant to the QA/QC objectives, the results for two of the samples (220 and 280 ppb) were less than three to five times the detection limit, and should have been verified by Method 239.2 (furnace). The analytical results for all three samples were an order of magnitude greater than the drinking water standard for lead. Conclusions drawn from the data do not change relative to the standard. Accordingly, the data are usable.
4. The spike recovery for filterable lead analyzed on May 8, 1987 was 146%, which was outside the upper acceptance limit of 125%. Seven of the nine samples analyzed exhibited less than detectable lead concentrations. The lead concentrations observed in the other two samples were greater than the detection limit of 5 ppb and less than the applicable standard of 50 ppb. Adjusting the data to reflect the elevated spike recovery does not change the conclusions based on the applicable standard. Accordingly, the data are usable.
5. The CCV for filterable lead analyzed on May 8, 1987 was 126%, which was above the upper acceptance limit of 110%. Seven of the nine samples exhibited less than detectable lead concentrations (i.e., less than 5 ppb), whereas the two samples whose lead concentrations were above the detection limit were also below the applicable standard of 50 ppb. Adjusting the data for the CCV does not change the conclusions relative to the applicable standard. The data are usable.

6. No preparation blank for filterable lead analyzed on May 8, 1987 was analyzed. All nine samples analyzed exhibited lead concentrations below the the applicable standard. The data appear to be in control and conclusions relative to the applicable standard do not change. Accordingly, the data are usable.
7. The LCS recovery for filterable cadmium analyzed on May 12, 1987 was 74%, which was below the lower acceptance limit of 85%. Eight of the nine samples analyzed were near or below the detection limit of 1ppb and an order of magnitude less than the the applicable standard of 10 ppb. The cadmium concentration exhibited by the other sample was two orders of magnitude higher than the applicable standard. Conclusions drawn from the data do not change relative to the applicable standard upon consideration of the LCS recovery. The data are usable.
8. The CCV for filterable cadmium analyzed on May 12, 1987 was 117%, which was above the upper acceptance limit of 110%. Eight of the nine samples analyzed for cadmium exhibited concentrations near or below the detection limit of 1 ppb, whereas the other sample exhibited a cadmium concentration two orders of magnitude greater than the applicable standard of 10 ppb. Adjusting the sample results for the depressed CCV recovery does not change the conclusions relative to the applicable standard. Accordingly, the data are usable.
9. No preparation blank for filterable cadmium analyzed on May 12, 1987 was analyzed. Eight of the nine samples analyzed

were an order of magnitude less than the applicable standard and the other sample was two orders of magnitude greater than the applicable standard. The data appear to be in control and are usable.

10. One sample analyzed for filterable arsenic on May 4, 1987 was out of the linear range of the instrument so it was rerun with other (soil) samples on May 4, 1987. The LCS, spike recovery, and CCV for three samples were below the lower acceptance limits specified in the QAPP. The arsenic concentration was observed to be 70 ppb, which is greater than the applicable standard of 50 ppb. Adjusting the sample result for the depressed LCS, spike recovery, and CCV does not change the conclusions relative to the applicable standard. The data are usable.
11. No preparation blank was analyzed for the filterable arsenic samples analyzed on May 4, 1987. All the filterable arsenic concentrations (except for the sample that was reanalyzed as discussed in item 10 above) were observed to be less than the applicable standard. All the other QA/QC objectives for these analyses were attained. The data appear to be in control and the conclusions drawn from the data relative to the applicable standard do not change. The data are usable.
12. No preparation blank was analyzed with filterable iron samples (batch one) analyzed on May 18, 1987. All the samples were observed to have less than detectable iron concentrations. All the other QA/QC objectives for these analyses were attained. The data appear to be in control. The lack of a

preparation blank does not change the conclusions drawn from the data relative to the applicable standard. Accordingly, the data are usable.

13. No preparation blank was analyzed with the second batch of filterable iron samples analyzed on May 18, 1987. All sample concentrations were observed to be greater than the applicable standard. All the other QA/QC objectives were met. The data appear to be in control. The lack of a preparation blank does not change the conclusions drawn from the data relative to the applicable standard. The data are usable.
14. No preparation blank was analyzed with the filterable zinc samples analyzed on May 14, 1987. All the other QA/QC objectives were met. Eight of the nine samples had less than detectable zinc concentrations, and one had a zinc concentration an order of magnitude greater than the applicable standard. The data appear to be in control. Conclusions relative to the applicable standard do not change due to the lack of a preparation blank. All the data are usable.
15. No preparation blank was analyzed along with the samples analyzed for filterable manganese of May 18, 1987. Seven of the nine samples had manganese concentrations greater than the applicable standard. The other two samples were below and just above the detection limit. All the other QA/QC objectives were met. The data appear to be in control. The lack of a preparation blank does not change the conclusions drawn from the data relative to the applicable standard. Accordingly, all the data are usable.

16. The LCS for filterable nickel analyzed on May 11, 1987 was 73.6% which was below the linear acceptance limit of 85%. eight of the nine samples had less than detectable nickel concentrations, whereas one sample was above the detection limit (700 ppb) but below the applicable standard of 1 ppm. Adjusting the data for the LCS results in all data still being below the applicable standard and does not change the conclusions relative to the applicable standards. All the data are usable.
17. The CCV for filterable nickel analyzed on May 11, 1987 was 85.6%, which was below the lower acceptance limit of 90%. Eight of the nine samples analyzed exhibited less than detectable nickel concentrations. The other sample result (700 ppb) was above the detection limit but below the applicable standard of 1000 ppb. Adjusting the data for the CCV does not change the conclusions drawn from the data relative to the applicable standard. Accordingly, all the data are usable.
18. No preparation blank was analyzed along with the filterable nickel samples analyzed on May 11, 1987. The data appear to be in control. The lack of a preparation blank does not change relative to the applicable standard. All the data are usable.
19. The CCV for filterable copper analyzed on May 11, 1987 was 89.5% which was just below the lower acceptance range of 90%. All the samples analyzed were less than the detection limit, 10 ppb, which was less than the applicable standard of 20 ppb.

Adjusting the data for the CCV does not change the conclusions drawn relative to the applicable standard. All the data are usable.

20. No preparation blank was analyzed along with the filterable copper sample analyzed on May 11, 1987. All the samples analyzed were less than the detection limit of 10 ppb, which was less than the applicable standard of 20 ppb. All the QA/QC objectives were met, with the exception of the CCV discussed above, which was 0.5% less than the lower acceptance limit. All the data appear to be in control. The data are usable.
21. The LCS for filterable chromium analyzed on May 13, 1987 was 83%, which was just below the lower acceptance limit of 85%. All the sample results were less than the detection limit of 5 ppb, which was an order of magnitude less than the applicable standard of 50 ppb. Adjusting the data for the LCS does not change the conclusions relative to the applicable standard. The data are usable.
22. The CCV for filterable chromium analyzed on May 13, 1987 was 81.5%, which was below the lower acceptance limit of 90%. All the analytical results for these samples were less than the detection limit of 5 ppb, which was an order of magnitude less than the applicable standard of 50 ppb. The conclusions drawn from the data relative to the applicable standard do not change upon adjustment of the data for the CCV.
23. No preparation blank was analyzed along with the filterable chromium samples analyzed on May 13, 1987. All the data

were below the detection limit and the QA/QC objectives were attained with the exception of the two minor excursions discussed in item 21 and 22 above. The data appear to be in control and are usable.

24. The holding time for samples analyzed for mercury on May 14, 1987 was exceeded by eight to ten days. Review of the QA/QC samples indicates that, with the exception of the CCV discussed below, all QA/QC objectives were attained. The analytical results were all below the detection limit and applicable standard. The data appear to be in control, and all are usable.
25. The CCV for mercury analyzed on May 14, 1987 was 88%, which was just below the lower acceptance limit of 90%. All the samples were less than the detection limit and the applicable standard. The conclusions relative to the applicable standard do not change. Accordingly, all data are usable.
26. The LCS for filterable antimony analyzed on May 11, 1987 was 117%, which was just above the upper acceptance limit of 115%. The data were all below the detection limit of 20 ppb. Adjusting the data for the LCS does not change the conclusions drawn from the data. All the data are usable.
27. The CCV for filterable antimony analyzed on May 11, 1987 was 111%, which was just above the upper acceptance limit of 110%. All the sample results were below the detection limit of 20 ppb. Adjusting the data for the CCV does not change the conclusions drawn from the data. The data are usable.

28. No preparation blank for filterable antimony was analyzed on May 11, 1987. All the analytical results for the samples were below the detection limit. All the QA/QC objectives, were attained, with the two exceptions discussed in items 27 and 28 above. The data appear to be in control and are usable.
29. The CCV for filterable silver analyzed on May 11, 1987 was 88%, which was just below the lower acceptance limit of 90%. All the data were less than the detection limit and applicable standard. Adjusting the data for the CCV does not change the conclusions relative to the applicable standard. All the data are usable.
30. No preparation blank for filterable silver was analyzed on May 11, 1987. All the analytical results for the samples were below the detection limit. All the QA/QC objectives were met, with the minor exception noted in item 29 above. The data appear to be in control and are usable.
31. The LCS for filterable selenium analyzed on May 6, 1987 was 78.5%, which was below the lower acceptance limit of 85%. All the data were below or just above the detection limit of 2 ppb, which was an order of magnitude less than the applicable standard of 10 ppb. Adjusting the data for the LCS does not change the conclusions drawn from the data relative to the applicable standard. The data are usable.
32. The CCV for filterable selenium analyses on May 6, 1987 was 80%, which was below the lower acceptance limit of 90%. All the data were below or just above the detection limit of 2 ppb. The detection limit was an order of magnitude less than

the applicable standard. Conclusions relative to the applicable standard do not change upon adjustment of the data based on the CCV. Accordingly, all the data are usable.

33. No preparation blank was analyzed for filterable selenium on May 6, 1987. All the analytical results were below or just above the detection limit which was an order of magnitude below the applicable standard. All the QA/QC objectives were attained, with the exceptions noted in items 31 and 32 above. The data appear to be in control. All the data are usable.
34. The holding time for the first batch of sulfate analyses analyzed on May 8, 1987 was exceeded by two to four days. All QA/QC objectives were met and the data appear to be in control. The data are used as indicators only, and conclusions relative to the applicable standard do not change. All the data are usable.
35. The holding time for the second batch of sulfate analyses analyzed on May 19, 1987 was exceeded by 13 to 15 days. All QA/QC objectives were attained, except that no spike was analyzed as noted below. Sulfate is used as an indicator parameter only, and conclusions relative to the applicable standard do not change. All the data are usable.
36. No spike for sulfate was analyzed on May 19, 1987. All other QA/QC objectives were met, with the exception noted in item 35 above. The data appear to be in control. Sulfate is used as an indicator parameter, and as such, conclusions relative to the applicable standard do not change. The data are usable.

37. The holding time for total dissolved solids analyzed on May 7, 1987 was exceeded by approximately 30 days. The other QA/QC parameter conducted was acceptable. Total dissolved solids is used as an indicator parameter only. Conclusions drawn from the data relative to the applicable standard do not change. All the data are usable.
38. No duplicate for total dissolved solids analyzed on May 7, 1987 was analyzed. The other QA/QC parameter conducted was acceptable. Total dissolved solids is used as an indicator parameter, and the conclusions drawn do not change. Accordingly, the data are usable.
39. The holding time for total dissolved solids analyzed on May 8, 1987 was exceeded by approximately 30 days. The other QA/QC parameter conducted was acceptable. Total dissolved solids is used as an indicator parameter only. Conclusions drawn from the data relative to the applicable standard do not change. All the data are usable.
40. No duplicate for total dissolved solids analyzed on May 8, 1987 was analyzed. The other QA/QC parameter conducted was acceptable. Total dissolved solids is used as an indicator parameter, and the conclusions drawn do not change. Accordingly, the data are usable.

In summary, all the Round 2 ground water data are usable, although several discrepancies in meeting the QA/QC objectives were identified. The data are of sufficient quality to meet the overall objectives for their use in this project.

Ground Water Analyses - Round 3 (Additional Ground Water Investigation Round 1)

Five ground water samples and one field duplicate were analyzed for nine parameters, and two ground water samples and one field duplicate were analyzed for eight additional parameters, resulting in a total of 78 analyses. The review of QA/QC analyses conducted during the third round of ground water analysis indicated that the QA/QC objectives specified in the QAPP were attained in most cases. In those cases where certain QA/QC objectives were not met, the associated sample results were determined to be usable in terms of the overall project objectives. The specific instances where the QA/QC objectives were not attained are presented below:

1. The CCV for cadmium analyzed on September 30, 1987 was 112%, which was just above the upper acceptance limit of 110%. Five of six sample results were below or just above the detection limit of 5 ppb. The other result was an order of magnitude above the applicable standard of 50 ppb. Adjusting the data for the CCV does not change the conclusions drawn based on the applicable standard. All the data are usable.
2. The CCV for nickel analyzed on September 19, 1987 was 85.2%, which was below the lower acceptance limit of 90%. Five of six samples were below or just above the detection limit of 10 ppb, and the other sample results was two orders of magnitude below the applicable standard of 1 ppm. Adjusting the data for the CCV does not change the conclusions relative to the applicable standard. The data are usable.

3. The LCS for chromium analyzed on October 5, 1987 was 84%, which was just below the lower acceptance limit of 85%. the LCS was within the EPA's 95% confidence interval. All the sample results were less than the detection limit of 5 ppb. The applicable standard was 50 ppb. Conclusions relative to the applicable standard do not change upon adjusting the data for the LCS. Accordingly, all the data are usable.
4. The CCV for chromium analyzed on October 5, 1987 was 89%, which was just below the lower acceptance limit of 90%. All the data were less than the detection limit of 5 ppb. The applicable standard for chromium was 50 ppb. Adjusting the data for the CCV does not change the conclusions relative to the applicable standards. All the data are usable.
5. The duplicate for varium analyzed on September 16, 1987 had a relative percent difference of 10.6 which was just outside the acceptance range of 10%. All the data were less than the detection limit and applicable standard of 1 ppm. All the other QA/QC data were acceptable. The data are usable.
6. The holding time for mercury analyzed on October 3, 1987 was exceeded by 24 days. All the other QA/QC objectives were attained. The sample results were all less than the detection limit of 0.2 ppb. All the data are usable.
7. The LCS for selinum analyzed on September 29, 1987 was 82%, which was just below the lower acceptance limit of 85%. The LCS was within the EPA's 95% confidence limit. All the sample results were less than the detection limit of 2 ppb, which was an order of magnitude less than the applicable

standard of 10 ppb. Adjusting the sample results for the LCS does not change the conclusions relative to the applicable standard. All the data are usable.

8. The CCV for selenium analyzed on October 3, 1987 was 89%, which was just below the lower acceptance limit of 90%. All the data were less than the detection limit of 2 ppb, which was an order of magnitude less than the applicable standard. Adjusting the data for the CCV does not change the conclusions relative to the applicable standards. All the data are usable.
9. The LCS for antimony analyzed on September 28, 1987 was 133%, which was above the upper acceptance limit of 115%. The LCS was within the EPA's 95% confidence limit. All the data were less than the detection limit of 20 ppb. Adjusting the data for the LCS does not change the conclusions drawn from the data relative to the applicable standard. Accordingly, the data are usable.
10. The CCV for arsenic analyzed on September 27, 1987 was 113.5%, which was just above the upper acceptance limit of 110%. The sample results were either below or just above the detection limit of 5 ppb, or an order of magnitude greater than the applicable standard of 50 ppb. The conclusions drawn from the data do not change relative to the applicable standard upon adjustment of the data for the CCV.
11. The holding time for total dissolved solids analyzed on September 10, 1987 was exceeded by 24 days. All the sample results were above the applicable standard of 500 ppm. Total

dissolved solids is used as an indicator parameter only. The conclusions drawn from the data relative to the applicable standard do not change due to the holding time being exceeded. All the data are usable.

12. No LCS was analyzed for total dissolved solids on September 10, 1987. All the data were above the applicable standard for total dissolved solids, which is used as an indicator parameter only. The conclusions drawn from the data relative to the applicable standard do not change due to the lack of an LCS. The data are all usable.
13. The holding time for sulfate analyzed on September 11, 1987 was exceeded by three days. The QA/QC analyses conducted for sulfate were all acceptable. The data appear to be in control. Sulfate is used as an indicator parameter. Consequently, conclusions relative to the applicable standard for sulfate do not change due to the holding time being exceeded, and all the data are usable.
14. No LCS was analyzed for sulfate on September 11, 1987. The QA/QC analyses conducted for sulfate were all acceptable. The data appear to be in control. Sulfate is used as an indicator parameter. The conclusions drawn from the data do not change due to the lack of an LCS. Accordingly, all the data are usable.

In summary, all the Round 3 ground water data are usable, although several discrepancies in meeting the QA/QC objectives were identified. The data are of sufficient quality to meet the overall objectives for their use in the project.

Ground Water Analyses - Round 4 (Additional Ground Water Investigation Round 2)

Five ground water samples and one field duplicate sample were analyzed for nine parameters, and two ground water samples and one field duplicate were analyzed for eight additional parameters, resulting in a total of 78 analyses. The review of QA/QC analyses collected during the fourth round of ground water analysis indicated that, for the most part, the QA/QC objectives were not met, thus associated sample results were determined to be usable relative to the overall objectives of the project. The specific instances where the QA/QC objectives were not met are discussed below.

1. The LCS for cadmium analyzed on December 8, 1987 was 82%, which was just below the lower acceptance limit of 85%. All the sample results were less than the detection limit of 1 ppb. The applicable standard was 10 ppb. Adjusting the data for the LCS does not change the conclusions drawn from the data relative to the applicable standard. The data are usable.
2. No preparation blank was analyzed for cadmium on December 8, 1987. All the data were less than the detection limit of 1 ppb, which was an order of magnitude less than the applicable standard of 10 ppb. The conclusions drawn from the data relative to the applicable standard do not change due to the lack of a preparation blank. Accordingly, all the data are usable.
3. No preparation blank was analyzed for arsenic on December 7, 1987. All but one of the sample results was less than the detection limit of 5 ppb. The other sample result was greater

than the applicable standard of 50 ppb. All the other QA/QC objectives were obtained. The lack of a preparation blank does not change the conclusions drawn from the data relative to the applicable standard. All the data are usable.

4. No preparation blank was analyzed for iron on December 4, 1987. The sample results were either less than or just above the detection limit of 100 ppb, or greater than the applicable standard of 300 ppb. All the other QA/QC objectives were attained. The conclusions drawn from the data relative to the applicable standard do not change due to the lack of a preparation blank. Accordingly, all the data are usable.
5. No preparation blank was analyzed for manganese on December 4, 1987. The sample results were all at least an order of magnitude greater than the applicable standard of 50 ppb. All other QA/QC objectives were attained. The conclusions drawn from the data relative to the applicable standard do not change due to a lack of a preparation blank. All the data are usable.
6. No preparation blank was analyzed for nickel on November 19, 1987. All but one of the sample results were at or below the detection limit of 10 ppb. The other sample result was below the applicable standard of 1 ppm. All the other QA/QC objectives were attained. The lack of a preparation blank does not change the conclusions drawn from the data relative to the applicable standard. Accordingly, the data are usable.
7. No preparation blank was analyzed for zinc on December 9, 1987. All but one of the sample results were at or below the

detection limit of 20 ppb. The other result was an order of magnitude greater than the applicable standard of 1 ppm. All the other QA/QC objectives were not. The conclusions drawn from the data relative to the applicable standard do not change due to a lack of a preparation blank. All the data are usable.

8. No preparation blank was analyzed for barium on December 4, 1987. All the sample results were less than the detection limit of 1 ppm. All the other QA/QC objectives were attained. The lack of a preparation blank does not change the conclusions relative to the applicable standard. All the data are usable.
9. The ICV for chromium on December 7, 1987 was 88%, which was just below the lower acceptance limit of 90%. All the sample results were less than the detection limit of 5 ppb. The applicable requirement was 50 ppb. Adjusting the data for the ICV does not change the conclusions relative to the applicable standard. All the data are usable.
10. No preparation blank was analyzed for chromium on December 7, 1987. The data were less than the detection limit of 5 ppb, which was an order of magnitude less than the applicable requirement of 50 ppb. All the QA/QC objectives, with the exception of that presented in item 9 above, were attained. The conclusions drawn from the data relative to the applicable standard do not change, due to the lack of a preparation blank. Accordingly, the data are usable.

11. No preparation blank was analyzed for selenium on December 4, 1987. All the analytical results were less than the detection limit of 2 ppb. The applicable standard was 10 ppb. The other QA/QC objectives were all met. The conclusions drawn from the data relative to the applicable standard do not change due to the lack of a preparation blank. All the data are usable.
12. No preparation blank was analyzed for silver on December 9, 1987. All the sample results were less than the detection limit and applicable standard of 5 ppb. The other QA/QC objectives were all attained. The conclusions drawn from the data relative to the applicable standard do not change due to the lack of a preparation blank. All the data are usable.
13. The LCS for antimony analyzed on December 8, 1987 was 83%, which was just below the lower acceptance limit of 85%. This result was within the EPA's 95% confidence limit. All the data were less than the detection limit of 20 ppb. Adjusting the data for the LCS does not change the conclusions drawn from the data. All the data are usable.
14. The CCV for antimony analyzed on December 8, 1987 was 116%, which was above the upper acceptance limit of 110%. All the sample results were less than the detection limit of 20 ppb. The conclusions drawn from the data do not change upon adjustment of the data for the CCV. Accordingly, all the data are usable.
15. No preparation blank was analyzed for antimony on December 8, 1987. All the data were less than the detection limit of 20

- ppb. The lack of a preparation blank does not change the conclusions drawn from the data. The data are all usable.
16. No preparation blank was analyzed for copper on November 30, 1987. All the results were less than the detection limit of 10 ppb. The applicable standard was 20 ppb. All the other QA/QC objectives were obtained. The conclusions drawn from the data relative to the applicable standard do not change due to the lack of a preparation blank. All the data are usable.
  17. No preparation blank for mercury was analyzed on November 23, 1987. All the sample results were less than the detection limit of 0.2 ppb. The applicable standard was 0.5 ppb. The other QA/QC objectives were met. The lack of a preparation blank does not change the conclusions drawn from the data relative to the applicable standard. Accordingly, the data are usable.
  18. No LCS for sulfate was analyzed on November 17, 1987. Sulfate is intended to be an indicator parameter only. All the other QA/QC objectives analyzed were attained. The conclusions drawn for the data relative to the applicable standard do not change due to the lack of an LCS. The data are usable.
  19. No LCS or blank was analyzed for total dissolved solids on November 16, 1987. Total dissolved solids is used as an indicator parameter only. All the data were at or above the applicable standard of 500 ppm. The conclusions drawn from the data relative to the applicable standard do not change due to the lack of an LCS or blank. All the data are usable.

In summary, all the Round 4 ground water data are usable, although several discrepancies in meeting the QA/QC objectives were identified. The data are of sufficient quality to meet the overall objectives for their use in the project.

### Additional Soils Analysis

In this round of analyses fifty-one soil samples were analyzed for six parameters, and 46 of these samples were also analyzed for percent total solids. Five of the samples were not analyzed for percent total solids due to insufficient sample volume. Soil samples were analyzed for characterization purposes; no state or federal standards exist for soil. QA/QC review of these analyses indicated that QA/QC objectives were met in 95 percent of the cases. The following narrative discusses the specific cases where the QA/QC objectives were not met.

1. The spike recoveries for lead were 0.0%, 0.0%, and 151.0% compared to the range of 100 ±35% specified by the QAPP. In each case, the sample concentration exceeded the spike concentration by a factor of four or more. The mechanics of the mathematical equation used to calculate spike recoveries often results in large variations in percent recovery occurring from small differences in analytical values.

For example: Sample # H0093

$$\begin{aligned}\% \text{ Recovery} &= \frac{\text{Spiked Sample Results (ppm)} - .9 (\text{Sample Result (ppm)})}{.1 (\text{Spike Added (ppm)})} \\ &= \frac{367 - .9 (391)}{.1 (100)} = 151.0\%\end{aligned}$$

If the spiked sample result had been 361 mg/kg instead of 367 mg/kg, the percent recovery would have been 100%. The difference between these two values does not change conclusions from the data relative to the objectives of the project. The same is true for the other two spiked samples: spiked sample results of 860 mg/kg and 661 mg/kg had percent recoveries of 0.0%, when spiked sample results

of 878.5 mg/kg and 671.5 mg/kg would have resulted in 100% recoveries.

All other QC data were within the appropriate guidelines. Data are usable in terms of the overall objectives of the project.

2. The preparation blank concentration for lead on June 30, 1988 was incorrectly transcribed as less than 200 ppm on page 0075 of the Laboratory Report. The concentration should read less than 20 ppm, which is acceptable according to the QAPP.
3. The preparation blank concentration for cadmium on June 30, 1988 was mistakenly recorded as less than 20 ppm on page 0075 of the Laboratory Report. The concentration was actually less than 2 ppm, which corresponds with QAPP guidelines.
4. The third of six CCV's for arsenic on July 13, 1988 was 117% compared to the acceptable range of  $100 \pm 10\%$ . Since this CCV was just above the upper limit, and all other CCV's before and after the third CCV were within the specified range, the data are usable, as intended, for characterization purposes.
5. The sixth of 14 CCV's for arsenic on July 18 and 19, 1988 was 116.6%, which was just above the upper limit of the QAPP- specified range of  $100 \pm 10\%$ . The CCV's before and after the sixth CCV on July 18 and 19 were all acceptable. The data are usable since they are intended for characterization purposes.
6. The preparation blank concentration for arsenic on July 13, 1988 was .95 ppm, which was greater than the detection limit of 5 ppm. OBG Laboratories believes that the arsenic

contamination was the result of aluminum contamination which resulted from a small piece of aluminum foil inadvertently falling into the preparation blank container. When D2 Arc background correction is used, as in this case, aluminum presence can cause a spectral interference with arsenic. All other blanks and preparation blanks were below detection limits. Data are usable for characterization purposes.

7. One duplicate sample for chromium had a RPD of 38.1% which was above the maximum RPD of 25%. The two other duplicate samples were acceptable as specified in the QAPP. Data are usable for characterization.
8. The preparation blank concentration for chromium on June 30, 1988 was recorded incorrectly on page 0075 of the Laboratory Manual as less than 50 ppm. The concentration should read less than 5 ppm, which is acceptable according to the QAPP.
9. The spike recoveries for zinc were 18.0%, 36.0%, and 174.0%, compared to the range of  $100 \pm 35\%$  specified by the QAPP. In each case, the sample concentration exceeded the spike concentration by a factor of four or more. The mathematical equation used to calculate spike recoveries has resulted in large percent recovery variations from small differences in analytical values. Spiked sample results of 270 mg/kg, 387 mg/kg, and 480 mg/kg had percent recoveries of 18.0%, 36.0%, and 174.0% respectively, when spiked sample results of 278.2, 393.4, and 472.6 would have resulted in percent recoveries of 100%. The differences between the two values

in each of the three sets do not change conclusions drawn from the data relative to the objectives of the project.

All other QC data were acceptable. Data are usable in terms of the overall objectives of the project.

10. The zinc concentration for the preparation blank on June 30, 1988 was transcribed incorrectly as less than 50 ppm on page 0075 of the Laboratory Report. The correct concentration was less than 5 ppm, which is acceptable under the QAPP.
11. One continuing calibration blank concentration for antimony on June 27, 1988 was 22 ppb, which was just above the 20 ppb detection limit. All other blanks, including continuing calibration blanks before and after the unacceptable one, were acceptable according to the QAPP. Data can be used for characterization purposes.

To summarize the QA/QC review of the additional soils analyses, although not all of the QA/QC objectives were attained, all data are usable for the objectives of the project.

## APPENDIX F

[illegible]





O'BRIEN & GERE ENGINEERS, INC.		TEST BORING LOG		REPORT OF BORING NO. B-4		SHEET 1 OF	
PROJECT LOCATION: Granite City, ILL.		SAMPLER TYPE: ASTM Method 1586-D		GROUND WATER DEPTH DATE ELEV. DEPTH DATE ELEV.			
CLIENT: NL Industries		FALL:		FILE NO.: 2844.012.005			
BORING CO.: FOREMAN: OBG GEOLOGIST: R. J. Foresti				BORING LOCATION: GROUND ELEVATION: DATES: STARTED: / /			
DEPTH		SAMPLE		SAMPLE DESCRIPTION		FIELD TESTING	
No.	DEPTH	BLOWS /6"	PENETR/ RECOVERY	"N" VALUE	START/ CHANGE DEPTH	EQUIPMENT INSTALLED	SAL. O/00
0		N/A	N/A		Black to grey fill, brick, slag, and cement fragments, sand and gravel, moist loose, from 0 to 4.5 feet.		
2							
4					Black to olive grey clay, trace silt, moist, cohesive, firm from 4.5 to 6.5 feet.		
6					Bottom of hole @ 6.5 feet.		
8							
10							
12							
14							

\* Selby tube taken from 4.5 feet to 6.5 feet.

[illegible]

O'BRIEN & GERE ENGINEERS, INC.					TEST BORING LOG		REPORT OF BORING NO. B-6		SHEET 1 OF	
PROJECT LOCATION: Granite City, ILL.					SAMPLER TYPE: ASTM Method 1586-D HAMMER: FALL:		GROUND WATER DEPTH DATE DEPTH DATE		ELEV. ELEV.	
CLIENT: NL Industries							FILE NO.: 2844.012.005			
BORING CO.: FOREMAN: OBG GEOLOGIST: R. J. Foresti					BORING LOCATION: GROUND ELEVATION: DATES: STARTED: / /					
					ENDED: / /					
DEPTH	SAMPLE				SAMPLE DESCRIPTION	STATUS CHANGE DEPTH	EQUIPMENT INSTALLED	FIELD TESTING		
	No.	DEPTH	BLOWS /6"	PENETR/RECOVERY				"N" VALUE	SAL. O/00	SP. COND.
0						Dark brown and gravel, silt, and stone fragments, fill, moist to loose from 0 to 4.5 ft.				
2										
4						Medium brown fine to medium sand, trace silt, moist loose, from 4.5 to 14 feet.				
6										
8										
10										
12										
14										
						Bottom of hole @ 14 feet.				

\* Shelby tube taken from 12 feet to 14 feet.





## APPENDIX G

# ANALYTICAL RESULTS - WASTE PILE

## KEY

<u>Description</u>	<u>Lab. No. (Sample No.)</u>	<u>Sample Type</u>
2501	D2325	Slag Pile Upper Strata
2502	D2326	"
2503	D2327	"
2504	D2328	"
2505	D2329	"
2506	D2330	"
2506 Leach	A9540	"
2507	D2331	"
2507 Leach	A9541	"
2508	D2332	"
2508 Leach	A9542	"
2509	D2333	"
2509 Leach	A9543	"
2510	D2334	"
2510 Leach	A9544	"
2500 (blank)	D2338	"
3601	D2335	SLLR Pile
3602	D2336	"
3602 Leach	A9545	"
3666	D2337	"
D2261 - D2276 Digestion	A8882	Slag Pile
D2261 - D2276 Leachate	A8883	"
D2277 - D2292 Digestion	A8884	"
D2277 - D2292 Leachate	A8885	"
Digestion	A8886	"
Digestion	A8887	"
9901	D2345	Drummed Material
9901 Leachate	A9546	"
9902	D2346	"

Note: A review of the analytical results for the wash pile samples relative to the QA/QC objectives specified in the QAPP is presented in Appendix E.



2044.012.517

**DESCRIPTION**

DATE COLLECTED=5-87 THROUGH 1-8-87 RECD. 2-10-87 DATE, NAME, SEX

Methodology: Formal Heuristic - 40 CFH, Fall 198, October 26, 1984

**QUESTIONING**

Samples in 18/1.

**Authentic.**

date May 22, 1961

1971, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 2542, 2543, 2544, 2545, 2546, 2547, 2548, 2549, 2550, 2551, 2552, 2553, 2554, 2555, 2556, 2557, 2558, 2559, 2560, 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, 2571, 2572, 2573, 2574, 2575, 2576, 2577, 2578, 2579, 2580, 2581, 2582, 2583, 2584, 2585, 2586, 2587, 2588, 2589, 2590, 2591, 2592, 2593, 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614, 2615, 2616, 2617, 2618, 2619, 2620, 2621, 2622, 2623, 2624, 2625, 2626, 2627, 2628, 2629, 2630, 2631, 2632, 2633, 2634, 2635, 2636, 2637, 2638, 2639, 2640, 2641, 2642, 2643, 2644, 2645, 2646, 2647, 2648, 2649, 2650, 2651, 2652, 26



# Laboratory Report

CLIENT N. L. INDUSTRIES

JOB NO. 2844.012.517

DESCRIPTION \_\_\_\_\_

DATE COLLECTED 1-5-87 through 1-8-87 DATE REC'D. 2-10-87

DATE ANALYZED \_\_\_\_\_

Description	D2261 to D2276 Digestion	D2261 to D2276 Leachate	D2277 to D2292 Digestion	D2277 to D2292 Leachate	Digestion	Digestion
Sample #	A8882	A8883	A8884	A8885	A8886	A8887
CADMIUM	126	0.06	28	0.02	19	35
COPPER	10000.	--	11000.	--	5800.	11000.
IRON	340000	--	300000	--	210000	270000
LEAD	15000.	312.	32000.	147.	33000.	37300.
MANGANESE	1140	--	804	--	1600	717
MERCURY	<0.5	<0.0025	<0.5	<0.0025	<0.5	<0.5
ZINC	2430	--	2100	--	1710	6940
CHROMIUM	7.5	<0.05	10.4	<0.05	23.2	7.8
ARSENIC	620	<0.05	900	<0.021	2200	1500
ANTIMONY	600.	--	1600.	--	410.	1400.
NICKEL	480	--	1210	--	337	459
SELENIUM	<2.	<0.02	<2.	<0.02	<2.	<2.
SILVER	5.8	<0.05	<5	<0.05	<5	6.7
BARIUM	212.	0.25	523.	0.49	1097.	641.

Methodology: Federal Register — 40 CFR, Part 136, October 26, 1984

Units: Digestion mg/kg  
Leachate mg/l

Comments:

Authorized: D. A. Bender

OBG Laboratories, Inc.  
Box 4942 / 1304 Buckley Rd. / Syracuse, NY / 13221 / (315) 457-1494

Date: May 22, 1987



# Laboratory Report

CLIENT N. L. INDUSTRIES

JOB NO. 2844.012.517

DESCRIPTION \_\_\_\_\_

DATE COLLECTED 1-5-87 through 1-8-87 DATE REC'D. 2-10-87

DATE ANALYZED \_\_\_\_\_

Description	9901	9902			
Leachate					
Sample #	A9546	D2346			
CADMIUM	10.19	2700.			
COPPER	--	89.			
IRON	--	7120.			
LEAD	1900.	237000.			
MANGANESE		106.			
MERCURY	<0.0025	<0.5			
ZINC		245000.			
CHROMIUM	<0.05	24.9			
ARSENIC	<0.005	<0.5			
ANTIMONY	--	81.			
NICKEL		20.3			
SELENIUM	<0.02	<2.			
SILVER	<0.05	15.5			
BARIUM	0.21	38.			

Methodology: Federal Register — 40 CFR, Part 136, October 26, 1984

Units: Digestion in mg/kg  
Leachate in mg/l

Comments:

OBG Laboratories, Inc.  
Box 4942 / 1304 Buckley Rd. / Syracuse, NY / 13221 / (315) 457-1494

Authorized: D. A. Brandon  
Date: May 22, 1987

## APPENDIX H

## ANALYTICAL RESULTS - SOILS (1)

## KEY

<u>Sample No.</u>	<u>Location</u>	<u>Depth (2)</u>	<u>Sample No.</u>	<u>Location</u>	<u>Depth</u>
D0994	1	0	D1032	34	6
D0995	1	6	D1033	32	9
D0996	2	0	D1034	29	0
D0997	2	6	D1035	29	6
D0998	4	0	D1036	30	0
D1002	5	0	D1037	30	6
D1003	5	6	D1038	31	0
D1004	6	0	D1039	31	6
D1005	6	6	D1040	33	0
D1006	8	0	D1041	33	6
D1007	8	6	D1042	35	0
D1012	13	0	D1043	35	6
D1013	13	6	D1046	38	0
D1014	14	0	D1047	38	6
D1015	14	6	D1048	37	1
D1016	15	0	D1049	39	1
D1017	15	6	D1050	40	1
D1018	16	0	D1051	41	1
D1019	16	6	D1052	42	1
D1020	18	0	D1053	43	0
D1021	18	6	D1054	43	6
D1022	20	0	D1055	44	0
D1023	20	6	D1056	44	6
D1024	21	0	D1057	45	0
D1025	21	6	D1058	45	6
D1026	22	0	D1059	46	0
D1027	22	6	D1060	7	0
D1028	25	0	D1061	7	6
D1029	25	6	D1062	46	6
D1030	26	0	D1063	24	0
D1031	26	6			

ANALYTICAL RESULTS - SOILS <sup>(1)</sup>

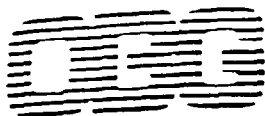
## KEY

(continued)

<u>Sample No.</u>	<u>Location</u>	<u>Depth</u> <sup>(2)</sup>	<u>Sample No.</u>	<u>Location</u>	<u>Depth</u>
D1064	24	6	D5697	104	0
D1065	32	0	D5698	104	6
D1066	32	6	D5699	110	0
D1067	34	0	D5700	110	6
D1094	3	0	D5701	140	1
D1095	3	6	D5702	117	0
D1096	38	0	D5703	117	6
D1097	28	6	D6727	110	0
D1098	12	0			
D1099	12	6			
D3600	19	0			
D3601	19	6			
D3602	26	9			
D3603	101	0			
D3605	111	0			
D3606	111	6			
D3607	36	0			
D3608	36	6			
D5387	101	6			
D5388	11	0			
D5389	11	6			
D5390	10	0			
D5391	10	6			
D5689	118	0			
D5690	118	6			
D5691	112	0			
D5692	112	6			
D5693	132	0			
D5694	132	6			
D5695	106	0			
D5696	106	6			

Notes: (1) A review of the analytical results for the soil samples relative to the QA/QC objectives specified in the QAPP is presented in Appendix E.

(2) The sample depth was 0 to 3 inches from grade;  
 6 indicates the sample depth was 0 to 6 inches from grade;  
 1 indicates the sample was a surface grab sample;  
 9 indicates the sample was a blank.



LABORATORIES, INC.

PAGE ONE

Laboratory  
ReportCLIENT Y. L. INDUSTRIESJOB NO. 2844.012.517

DESCRIPTION \_\_\_\_\_

DATE COLLECTED 1-5-87 through 1-8-87DATE REC'D. 2-10-87

DATE ANALYZED \_\_\_\_\_

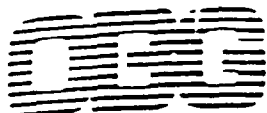
Sample #	LEAD	TOTAL PERCENT. SOLIDS			
D0994	930.	73.0			
D0995	720.	79.7			
D0996	440.	83.6			
D0997	330.	81.5			
D0998	2900.	98.6			
D0999	900.	91.5			
D1002	560.	84.0			
D1003	430.	86.3			
D1004	2100.	79.5			
D1005	530.	80.6			
D1006	260.	82.5			
D1007	230.	86.7			
D1012	240.	83.5			
D1013	66.	87.9			
D1014	480.	93.3			
D1015	150.	96.5			
D1016	1300.	84.0			
D1017	41000.	84.8			
D1018	2500.	78.9			
D1019	690.	79.9			
D1020	470.	77.9			

Methodology: Federal Register — 40 CFR, Part 136, October 26, 1984

Units: mg/kg

Comments:

OBG Laboratories, Inc.  
Box 4942 / 1304 Buckley Rd. / Syracuse, NY / 13221 / (315) 457-1494Authorized: D. A. BermanDate: May 21, 1987



LABORATORIES, INC.

PAGE TWO

Laboratory  
ReportCLIENT N. L. INDUSTRIESJOB NO. 2844.012.517

DESCRIPTION \_\_\_\_\_

DATE COLLECTED 1-5-87 through 1-8-87 DATE REC'D. 2-10-87

DATE ANALYZED \_\_\_\_\_

Sample #	LEAD	TOTAL PERCENT SOLIDS			
D1021	12000.	81.5			
D1022	1140.	75.7			
D1023	450.	82.1			
D1024	8180.	88.4			
D1025	3290.	88.7			
D1026	1580.	80.7			
D1027	60.	81.7			
D1028	130.	93.6			
D1029	60.	79.5			
D1030	510.	89.7			
D1031	420.	91.4			
D1032	270.	*			
D1033	220.	100.			
D1034	710.	78.5			
D1035	470.	79.6			
D1036	400.	83.0			
D1037	140.	83.4			
D1038	300.	77.3			
D1039	280.	79.7			
D1040	610.	79.3			
D1041	490.	80.6			

Methodology: Federal Register — 40 CFR, Part 136, October 26, 1984

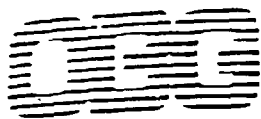
Units: mg/kg

Comments: \*No sample remaining after lead analysis

Authorized: D. A. BrondinoDate: May 21, 1987

CBG Laboratories, Inc.

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LABORATORIES, INC.

PAGE THREE

CLIENT W. L. INDUSTRIESJOB NO. 2344.012.517

DESCRIPTION \_\_\_\_\_

DATE COLLECTED 1-5-87 through 1-8-87DATE REC'D. 2-10-87

DATE ANALYZED \_\_\_\_\_

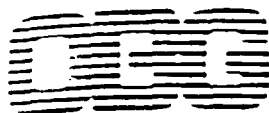
Sample #	LEAD	TOTAL PERCENT SOLIDS			
D1042	290.	75.2			
D1043	110.	84.9			
D1046	1430.	98.7			
D1047	5210.	89.8			
D1048	2120.	93.9			
D1049	2340.	87.5			
D1050	110000.	87.2			
D1051	6880.	91.8			
D1052	200.				
D1053	2750.	83.8			
D1054	3250.	80.6			
D1055	49.	78.0			
D1056	72.	78.9			
D1057	460.	80.0			
D1058	1030.	78.3			
D1059	1260.	67.1			
D1060	320.	78.7			
D1061	270.	79.8			
D1062	1080.	75.0			
D1063	200.	83.4			
D1064	91.	88.3			

Methodology: Federal Register — 40 CFR, Part 136, October 26, 1984

Units: mg/kg

Comments: \*No sample remaining after lead analysis

OBG Laboratories, Inc.  
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Date: May 21, 1987



LABORATORIES, INC.

PAGE FOUR

CLIENT N. L. INDUSTRIES

# Laboratory Report

JOB NO. 2944.012.517

DESCRIPTION \_\_\_\_\_

COLLECTED 1-5-87 through 1-8-87 DATE REC'D. 2-10-87

DATE ANALYZED \_\_\_\_\_

Sample #	LEAD	TOTAL PERCENT SOLIDS			
D1065	1330.	84.8			
D1066	1350.	88.0			
D1067	400.	78.4			
D1094	460.	83.2			
D1095	600.	81.6			
D1096	580.	80.0			
D1097	580.	82.2			
D1098	750.	76.3			
D1099	670.	79.3			
D3600	280.	98.7			
D3601	190.	86.3			
D3602	9.	100.			
D3603	2900.	76.7			
D3605	1760.	71.0			
D3606	1500.	82.9			
D3607	380.	83.4			
D3608	270.	89.0			

Methodology: Federal Register — 40 CFR, Part 136, October 26, 1984

Units: mg/kg

Comments:

DBG Laboratories, Inc.  
Box 4942 / 1304 Buckley Rd. / Syracuse, NY / 13221 / (315) 457-1494

Authorized: D. A. Bender

Date: May 21, 1987





# Laboratory Report

CLIENT N. L. GRANITE CITY JOB NO. 2844.012.517

DESCRIPTION 5-110-0 Soil Sample - EP TOX

DATE COLLECTED 4-7-87 DATE REC'D. 6-5-87 DATE ANALYZED \_\_\_\_\_

Sample #

D6727

Detection  
Limits  
(ppm)

ARSENIC

0.09

0.005

BARIUM

0.2

0.2

CADMIUM

<0.02

0.02

CHROMIUM

<0.05

0.05

LEAD

<0.20

0.20

SELENIUM

<0.002

0.002

SILVER

<0.01

0.01

## Notes:

1. Mercury was not analyzed due to a lack of sample size.
2. Detection limits have been modified because QA/QC objectives for leachates are not listed in the QAPP.
3. ~~With the exception of Arsenic, percent recoveries for spikes are post leachate recoveries. A pre-leachate spike showed very low percent recoveries.~~

Methodology: Federal Register — 40 CFR, Part 136, October 26, 1984

Units: mg/l

## Comments:

OBG Laboratories, Inc.  
Box 4942 / 1304 Buckley Rd. / Syracuse, NY / 13221 / (315) 457-1494

Authorized: D. A. Berdon

Date: July 1, 1987



# Laboratory Report

CLIENT N L INDUSTRIES, INC.JOB NO. 2844.012.517DESCRIPTION SoilsDATE COLLECTED 4-7-87DATE REC'D. 4-16-87

DATE ANALYZED \_\_\_\_\_

			Sample #	TOTAL LEAD	TOTAL PERCENT SOLIDS		
<u>I D</u>	<u>I D</u>	Sample Type					
1	2						
118	0	5	D5689	1150.	76.2		
118	6		D5690	280.	82.9		
112	0		D5691	123.	90.5		
112	6		D5692	41.	91.9		
132	0		D5693	193.	84.0		
132	6		D5694	198.	86.1		
106	0		D5695	760.	79.6		
106	6		D5696	420.	80.1		
104	0		D5697	630.	85.8		
104	6		D5698	330.	86.5		
110	0		D5699	2500.	80.4		
110	6	↓	D5700	1270.	81.4		
140	0	6	D5701	7900.	96.3		
117	0	5	D5702	840.	81.1		
117	6	5	D5703	280.	83.0		

Methodology: Federal Register — 40 CFR, Part 136, October 26, 1984

Units: **mg/kg**

Comments:

OBG Laboratories, Inc.  
Box 4942 / 1304 Buckley Rd. / Syracuse, NY / 13221 / (315) 457-1494Authorized: D. A. BrundageDate: May 26, 1987



# Laboratory Report

CLIENT NL GRANITE CITY JOB NO. 2844.015.510

DESCRIPTION \_\_\_\_\_

DATE COLLECTED 6-6-88 DATE REC'D. 6-6-88 DATE ANALYZED \_\_\_\_\_

Description	Sample #	LEAD	CADMIUM	ARSENIC	CHROMIUM	ZINC	ANTIMONY	PERCENT TOTAL SOLIDS			
D0994	H0043	725.	4.	22.7	27.	715.	6.	98.			
D0996	H0044	362.	<2.	11.6	17.	230.	4.	99.			
D1094	H0045	287.	<2.	9.6	17.	225.	2.	99.			
D0998	H0046	1970.	3.	8.1	113.	394.	3.	100.			
D1002	H0047	907.	3.	6.1	20.	448.	3.	100.			
D1004	H0048	1390.	6.	13.1	37.	941.	5.	100.			
D1060	H0049	330.	2.	8.1	17.	340.	5.	99.			
D1006	H0050	230.	<2.	8.3	15.	120.	2.	99.			
D5390	H0051	3810.	6.	52.4	41.	1430.	48.	99.			
D5388	H0052	1010.	4.	25.8	35.	728.	6.	98.			
D1098	H0053	611.	8.	2.7	39.	1240.	4.	99.			
D1012	H0054	165.	3.	9.3	17.	280.	2.	99.			
D1014	H0055	449.	<2.	19.0	85.	260.	8.	100.			
D1016	H0056	14800.	<2.	71.1	11.	142.	52.	97.			
D1018	H0057	2110.	5.	23.4	31.	586.	15.	99.			
D1020	H0058	630.	10.	12.6	72.	2080.	4.	99.			
D1022	H0060	965.	3.	61.8	50.	298.	7.	99.			
D1024	H0061	5270.	5.	53.3	142.	738.	27.	99.			
D1026	H0062	2570.	2.	11.5	46.	212.	6.	99.			
D1063	H0063	173.	2.	7.2	33.	637.	4.	99.			

Methodology: Federal Register -- 40 CFR, Part 136, October 26, 1984

Units: **mg/kg**

Comments:

Authorized:

*D B Borden*

Date: **July 20, 1988**



# Laboratory Report

CLIENT NL GRANITE CITY JOB NO. 2844.015.510

DESCRIPTION \_\_\_\_\_

DATE COLLECTED 6-6-88

DATE REC'D 6-6-88

DATE ANALYZED \_\_\_\_\_

Description	Sample #	LEAD	CADMIUM	ARSENIC	CHROMIUM	ZINC	ANTIMONY	PERCENT TOTAL SOLIDS
D1028	H0064	139.	<2.	14.6	22.	202.	4.	100.
D1030	H0065	567.	<2.	27.2	62.	146.	8.	99.
D1096	H0066	531.	3.	9.1	38.	365.	8.	99.
D1034	H0067	612.	4.	9.1	22.	47.	9.	99.
D1036	H0068	318.	<2.	7.8	37.	404.	7.	99.
D1038	H0069	235.	3.	8.7	20.	332.	5.	98.
D1065	H0070	1180.	9.	12.2	107.	685.	60.	99.
D1040	H0071	580.	2.	8.4	24.	263.	6.	99.
D1067	H0072	343.	2.	8.4	19.	335.	6.	99.
D1042	H0073	275.	<2.	15.1	19.	242.	5.	99.
D5697	H0074	644.	4.	10.7	26.	693.	5.	100.
D5695	H0075	620.	5.	3.1	33.	895.	5.	99.
D3603	H0076	2380.	5.	34.9	32.	695.	31.	99.
D5699	H0077	2430.	5.	32.6	33.	592.	19.	100.
D3605	H0078	1430.	5.	25.7	26.	797.	18.	98.
D5691	H0079	112.	<2.	5.4	27.	124.	3.	100.
D5702	H0080	735.	2.	11.6	28.	426.	6.	99.
D5689	H0081	1050.	12.	15.0	76.	2540.	7.	99.
D5693	H0082	205.	<2.	4.7	20.	233.	5.	-
D3607	H0083	246.	2.	6.8	21.	325.	3.	-
D1048	H0084	3150.	4.	2.85	696.	476.	18.	99.

Methodology: Federal Register — 40 CFR, Part 136, October 26, 1984

Units: **mg/kg**

Comments:

OBG Laboratories, Inc.  
Box 4942 / 1304 Buckley Rd / Syracuse, NY / 13221 / (315) 457-1494

Authorized:

*D. N. Bunker*

Date:

July 20, 1988



# Laboratory Report

CLIENT NL GRANITE CITY JOB NO. 2844.015.510

DESCRIPTION \_\_\_\_\_

DATE COLLECTED 6-6-88

DATE REC'D 6-6-88

DATE ANALYZED \_\_\_\_\_

Description	Sample #	LEAD	CADMIUM	ARSENIC	CHROMIUM	ZINC	ANTIMONY	PERCENT TOTAL SOLIDS			
D1046	H0085	766.	<8.	5.5	24.	247.	<8.	-			
D1049	H0086	1590.	4.	5.9	363.	605.	7.	94.			
D1050	H0087	95500.	4.	22.0	9.	294.	495.	-			
DS701	H0088	5710.	2.	15.3	27.	387.	11.	99.			
D1051	H0089	6940.	<2.	8.3	26.	363.	29.	99.			
D1052	H0090	124.	3.	40.8	38.	766.	4.	99.			
D1053	H0091	2920.	<2.	9.3	20.	258.	10.	97.			
D1055	H0092	19.	<2.	3.3	12.	67.	3.	-			
D1057	H0093	391.	3.	7.4	33.	514.	4.	97.			
D1059	H0094	1090.	4.	9.9	30.	827.	10.	94.			

Methodology: Federal Register — 40 CFR, Part 136, October 26, 1984

Units: mg/kg

Comments:

OBG Laboratories, Inc.  
Box 4942 / 1304 Buckley Rd / Syracuse, NY / 13221 / (315) 457-1494

Authorized

*D. A. Borden*

Date:

July 20, 1988

## APPENDIX I

## ANALYTICAL RESULTS - SURFACE WATER

### KEY

<u>Description</u>	<u>(Sample No.)</u>	<u>Sample Type</u>
7-001	B1530	Stormwater Sediment
7-002	B1531	"
7-003	B1532	"
7-004	B1533	"
8-001	B1534	Stormwater
8-002	B1535	"
8-003	B1536	"
8-004	B1537	"

Note: A review of the analytical results for the surface water samples relative to the QA/QC objectives specified in the QAPP is presented in Appendix E.



# Laboratory Report

CLIENT N L INDUSTRIES - GRANITE CITY

JOB NO. 2844.012.517

DESCRIPTION

DATE COLLECTED 5-5-87

DATE REC'D. 5-7-87

DATE ANALYZED

**Methodology:** Federal Register — 40 CFR, Part 136, October 26, 1984

Comments:

OBG Laboratories, Inc.  
Box 4942 / 1304 Buckley Rd. / Syracuse, NY / 13221 / (315) 457-1494

Units: mg/kg for 7-001, 7-002.  
7-003, 7-004

mg/1 for 8-001

**Authorized:**

Date: June 1, 1987



## APPENDIX J

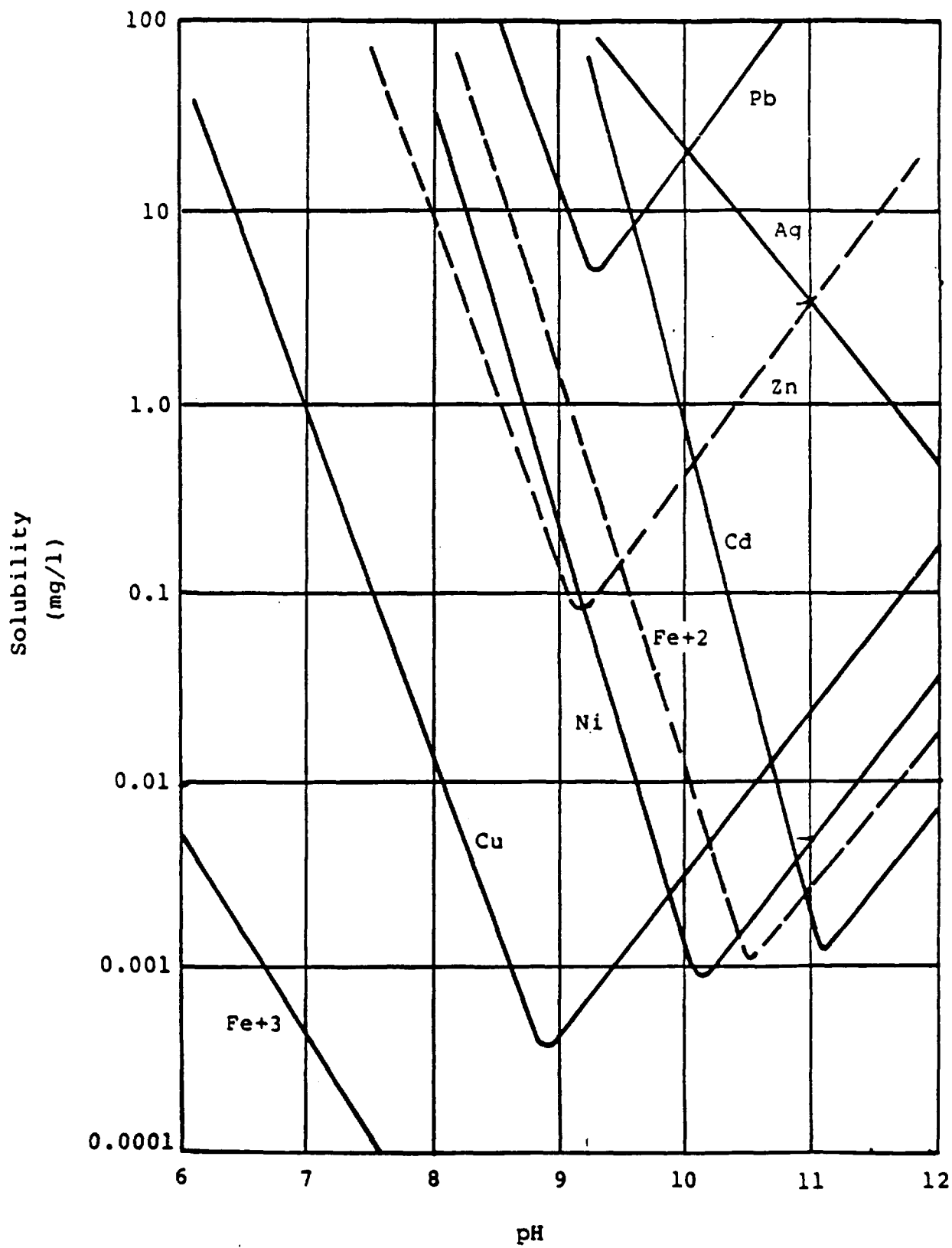


FIGURE 7-4

SOLUBILITIES OF METAL HYDROXIDES AS A FUNCTION OF pH

## APPENDIX K

**LEAD CONTAMINATION OF SURFACE SOILS  
IN URBAN AREAS**

**A LITERATURE SEARCH**

**DECEMBER 1986**

**O'BRIEN & GERE ENGINEERS, INC.  
1304 BUCKLEY ROAD  
SYRACUSE, NY 13221**

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- 1 Estimated Atmospheric Lead Emissions for the United States, 1981, and the World, 1979
- 2 Lead Dust On or Near Heavily Traveled Roadways
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- 4 Lead Dust in Residential Areas

### FIGURES

- 1 Lead Concentration as a Function of Distance from a Lead Smelter
- 2 Blood Lead Levels as a Function of Distance from a Lead Smelter in Idaho

### BIBLIOGRAPHY

## SECTION 1 - INTRODUCTION

Recognized for centuries to be a cumulative metabolic poison (Posner et al., 1978), lead is ubiquitous in the modern environment (Nriagu, 1978). As a population, children have the highest risk of environmental lead intoxication. Children have the greatest potential for exposure, due largely to play habits, etc., and the greatest physiological susceptibility to lead (U.S. EPA, 1977). Clinical effects of excessive environmental lead exposure - which include impairment of the renal, hemopoietic, and nervous systems (Waldron and Stofen, 1974) - are well documented. Subclinical effects of undue lead absorption are, however, less well understood. Few studies have provided data on the interactions between lead metabolism and subclinical and threshold effects.

Since lead issues from a multiplicity of sources (point (smelters) and non-point (automobiles)), it has proven difficult to quantify individual exposures and establish a dose response relationship between environmental lead concentrations and subtle changes in human health (Roberts et al., 1974). Quite naturally concern has arisen that continuous exposure to widespread environmental contamination may be resulting in adverse health effects, particularly in children. What follows is a summary of current information on environmental and health issues relative to lead contamination.

## SECTION 2 - LEAD SOURCES

It is likely that atmospheric lead emissions have increased by a factor of 2,000 since the pre-Roman era. Dramatic increases in global atmospheric lead concentrations have occurred since the 1920's (U.S. EPA, 1984).

Naturally occurring lead in soil ranges in concentration from approximately 8 to 25 micrograms/gram. In rural areas, total soil lead concentrations range from 10 to 30 micrograms/gram, whereas in urban areas, total soil lead is found in background concentrations of 150 to 300 micrograms/gram (U.S. EPA, 1984). The rate and extent of accumulation of pollutant lead within the vicinity of sources is dependent on several factors, including (Nriagu, 1978):

1. The rate at which lead is released at the source.
2. The ability of the atmosphere to disperse emissions; that is, lead accumulation is a function of air turbulence, wind speed, rainfall, mixing height, and the fallout velocity of lead particulates.
3. Wind direction and distance from the source of lead emissions.
4. The erodability of surficial deposits and soils. Soils retain lead strongly and are the major sink for pollutant lead (Nriagu, 1978). Lead emissions deposited on soils are generally retained within the top few centimeters; lead content around industrial sources exhibits a sharp decline with depth on the soil profile. Consequently, aeolian and fluvial action are major secondary mechanisms of lead dispersion in the environment contributing to atmospheric and aquatic

pollution. The half-life of pollutant lead in soils is relatively short. Roberts and Goodman (1973) estimate the half-life of lead in soils at less than 20 years. The time for complete turnover is also on the order of a few decades (Lockertz, 1974).

As indicated in Table 1, environmental lead emanates from many sources. In 1981, the combustion of gasoline accounted for 91.4% of all lead emissions in the U.S. This was followed by coal combustion and primary lead smelting, both representing 1.4% of total U.S. emissions, waste oil combustion at 1.2%, and secondary lead smelting at 0.9%. The decline in the use of leaded gasolines in the U.S. has resulted in a corresponding decrease in lead emissions from the combustion of gasoline. Similarly, a decrease in emissions from stationary sources has also been observed due primarily to control of stack emissions (U.S. EPA, 1984).

Emissions from automobiles using leaded gasoline are also significant in terms of surface soil lead contamination. Tables 2 and 3 present soil lead concentrations attributed to gasoline combustion. Linzon et al. (1976) collected soil samples from 65 major street intersections throughout a large urban area in southern Ontario, Canada. They reported an average lead concentration of 292 parts per million (dry weight) in the upper 2.5 centimeters, and 148 parts per million (dry weight) in the layer from 10 to 15 centimeters below grade. Other investigators have observed lead in surface soils ranging from 30 to 2000 micrograms/gram in excess of background levels within 25 meters of the roadside (U.S. EPA, 1984). Surface soil lead concentration generally decreases exponentially up to 25 meters from the edge of the road.

Concentrations of soil lead to a depth of 5 centimeters in areas of the U.S. were shown in one study to range from 150 to 500 micrograms Pb/gram dry weight near roadways (i.e., within 8 meters). By contrast, lead in dusts deposited on or near heavily travelled highways show levels in major U.S. cities ranging up to 8000 micrograms Pb/gram and higher (U.S. EPA, 1984).

In residential areas, exterior dust lead levels are approximately 1000 micrograms/gram or less if contaminated only by atmospheric lead. Levels of lead in house dust can be significantly elevated. A study of house dust samples in Boston and New York City indicated levels ranging from 1000 to 2000 micrograms Pb/gram. Table 4 presents lead concentrations in dust in residential areas. Some soils adjacent to houses with exterior lead-based paints may have lead concentrations greater than 10,000 micrograms/gram (U.S. EPA, 1984).

In general, the concentration of lead in air, dust and soil are elevated well above urban background levels, sometimes by several orders of magnitude, within the vicinity of smelters. Although elevated lead values have been found in soils at distances exceeding 25 kilometers from the smelter (Bolter et al., 1973; Koirtzohann et al., 1975), most intense lead deposition occurs within a radius of a few miles from the smelter site. Within a 1.0 kilometer radius of smelters, the rate of lead accumulation generally ranges from 0.1 milligrams/square meter-day to well over 100 milligrams/square meter-day (Nriagu, 1978). The lead content of dustfalls around smelters may exceed 10% by weight (Roberts et al., 1974) while the lead content of the topsoils around industrial source installations may at times exceed 3% or that of recovery grade ore.

Figure 1, reproduced from Roberts et al. (1974), illustrates some typical results. Air, dust and soil lead levels are shown as a function of distance from the smelter site. Generally, air, dust, and soil lead contents decrease exponentially with distance from the smelter site. Note that the risk of lead absorption decreases in a similar fashion, Figure 1d.

Several authors (Bolter et al., 1972; Hemphill et al., 1974; Rolfe and Jennett, 1975; and Roberts et al., 1974) suggest fugitive emissions (e.g., from trucking, hauling, and the re-entrainment of contaminated soils by wind gusts) are the primary sources of lead within the first few kilometers of lead smelters. Beyond this area, stack emissions become the primary source of the excess lead in soils.

### SECTION 3 - ENVIRONMENTAL MOBILITY OF LEAD

The physicochemical forms of lead determine the reaction mechanism, reaction rates, and the bioavailability, hence the impact of pollutant lead on the aquatic ecosystem and the potential mobility of lead in ground water. Naturally occurring lead is commonly regarded as geochemically immobile (Rickard and Nriagu, 1978); the low concentrations of lead in surface waters (Durum et al., 1971; Chow, 1978) suggest that lead is not readily mobilized during chemical weathering of geological materials. In the earth's crust, lead primarily occurs in potassium feldspars and micas of igneous and metamorphic rocks; with the exception of biotite, these minerals are fairly resistant to chemical weathering (Nriagu, 1978). Pollutant lead also appears to be environmentally immobile, at least from the standpoint of aqueous solubility. As mentioned earlier, automobile lead emissions deposited on soils are generally retained within the top few centimeters. Again, soils represent the major sink for pollutant lead (Nriagu, 1978).

Processes which control the distribution of lead in soil and aquatic environments have been considered in detail by Rickard and Nriagu (1978), Krauskopf (1956), Tsunagai and Nazaki (1971), Swanson et al. (1966), Leland et al. (1973), Ferguson and Bubela, (1974), Rashid (1974), Hem (1976), Hem and Durum (1973), Lagerwerff and Brower (1972, 1973), Santillan-Medrano and Jurinak (1975), Soldatini et al. (1976), Riffaldi et al. (1976) and Gerritse and Van Driel, (1984). The available information points to the probable interactions responsible for controlling lead levels as being:

1. Formation of lead-inorganic anion complexes;
2. Formation of lead-organic ligand complexes;
3. Dissolution and precipitation of inorganic and organic lead compounds;
4. Sorption onto hydrous and clay colloids;
5. Sorption onto organic colloids and particulates;
6. Decomposition of organic biomass to liberate associated lead; and
7. Co-precipitation of lead with other inorganic mineral phases.

Few data are available, however, to indicate the relative importance of these mechanisms in regulating the concentration of lead in surface and ground waters and the retention of lead by soils.

Bittel and Miller (1974), using pure clay systems, reported selectivity coefficients of Pb, Cd, and Ca ions on montmorillonite, illite, and kaolinite. Their data show that, in the systems studied, Pb was preferentially adsorbed over Ca.

Lagerwerff and Brower (1972, 1973) studied the exchange reactions of both Pb with aluminum, calcium, and sodium ions in three soils. A Gapon-type equation was found to describe the reactions. In the sodium system, Pb was found to precipitate. The authors speculated that  $Pb(OH)_2$  precipitated with other minor co-precipitates. The solubility of the solid lead phase was noted to increase with decrease in pH and the concentration of salt.

Soldatini et al. (1975) and Riffaldi et al. (1975) studied lead adsorption by 12 soils. Adsorption was found to conform to Langmuir and Freundlich isotherms over a large range of lead concentrations.

Organic matter and clays were the dominant constituents contributing towards adsorption maxima for the soils.

Gerritse and Van Driel (1985) studied the relationship between adsorption of lead, organic matter, and pH in 33 temperate soils. The distribution coefficients were directly related to organic matter and pH at three different ionic strengths of soil extractants. The exchangeable lead fraction was found to lie within the range of 1 to 5% of total lead.

Santillan-Medrano and Jurinak (1975) examined solid phase lead formation in soils, with particular attention given to the formation of hydroxide, carbonate and phosphate compounds. Pb solubility decreased in soils as pH increased; the lowest solubility was reported for calcareous soils (attributed to lead carbonate formation). In non-calcareous soils, hydroxide and phosphate compounds appeared to control lead solubility.

The importance of indigenous phosphate in controlling lead in soil solution was investigated by Nriagu (1972, 1973a, 1973b). His thermodynamic data suggests that  $Pb_5(PO_4)_3X$  where X=halide, hydroxide, etc., are important in controlling the fate of lead. In the presence of chloride ion, he suggests  $Pb_5(PO_4)_3Cl$  is a stable form of lead i.e. natural systems.

At present there is considerable disagreement concerning the extent to which lead in natural waters is present in soluble form as distinct from being associated with suspended or particulate matter (Stumm and Billinski, 1972; Florence and Batley, 1976). However, field studies indicate the importance of particulate forms in the transport of lead in the watersheds of lead smelters.

Research by Foil (1973) determined the forms and amounts of heavy metals transported from a watershed containing one active lead and zinc smelter. Studies were conducted to determine water quality during both dry weather and runoff conditions, and sediment samples were analyzed for their metal contents. The findings indicated that metals were transported during dry weather in their dissolved state, with lead being transported to a limited extent in particulate form. During storm runoff lead, zinc and copper were transported mainly as suspended solids.

Similar findings have been reported by Monroe et al. (1976) and used to develop a model to simulate the movements of Pb, Cd, Zn, Cu and S through a watershed adjacent to a lead mine and smelter.

In a more recent study, Benes et al. (1985), examined the migration and specification of lead in a river system heavily polluted from a smelter. Three forms of lead were distinguished: dissolved labile ( $\text{Pb}$ ,  $\text{PbOH}^+$ ,  $\text{PbCO}_3$ ); dissolved-bound (colloids or strong complexes); and particulate (retained by 0.40 micron membrane filter). Labile forms represented a very significant fraction of lead input from direct washout of atmospheric deposits. In contrast, most lead from urban runoff and mining was in particulate or bound forms. Concentrations of dissolved lead significantly exceeded the range of concentrations commonly encountered in surface waters (Chow, 1978) or calculated from the solubilities of sparingly soluble compounds of lead stable in such waters (Hem and Durum, 1973; Hem, 1976; Pagenkopf, 1979). The authors conclude that the dissolved lead is not controlled by the solubilities of lead compounds but rather by the adsorption on

suspended solids. The migration and speciation of lead was strongly controlled by water flow rate. With increasing flow rate, the concentrations of particulate and labile lead increased while the concentrations of bound forms decreased. Rapid removal of lead by sedimentation occurred during low flow conditions.

## SECTION 4 - HEALTH AND ENVIRONMENTAL CONSIDERATIONS

Numerous epidemiological studies confirm that people living in the vicinity of smelters have, on the average, an increased body burden of lead (Landrigan et al., 1975; 1976; Roberts et al., 1974; Baker et al., 1977; Roels et al., 1978; and Lansdown et al., 1974). Children in particular appear to be at risk of undue lead absorption. For example, Landrigan et al. (1975) reported on the blood lead levels of a random sample of persons in all age groups living near a lead smelter in El Paso, Texas. A blood lead level of 40 micrograms/100 milliliters, considered by the authors to be indicative of elevated lead absorption, was found in 53% of the children one to nine years of age living within 1.6 kilometers of the smelter and 18% of those from 1.6 to 6.6 kilometers. Beyond 6.6 kilometers blood lead concentrations in children were lower than 40 micrograms/100 milliliters. Blood lead concentrations in adults were all lower than 40 micrograms/100 milliliters. Children residing in contaminated areas also demonstrated higher lead in hair than comparison children living in uncontaminated areas. The authors suggest that particulate lead in dust and air accounted for most of the undue lead absorption in the children.

In a similar study, Landrigan et al. (1975) found that children living near a lead smelter in Kellogg, Idaho, demonstrated undue lead absorption and consequent adverse biological effects. Increased levels of erythrocyte protoporphyrin, anemia, and motor nerve conduction were found among children with elevated blood lead levels. Increased absorption of lead ( $\geq 40$  micrograms/100 milliliters) was found in 99% of

one to nine years old living within 1.6 kilometers of the Idaho smelter (Figure 2).

To put the blood lead levels observed in these studies in perspective, note that the U.S. EPA (1977) has concluded that the maximum safe blood lead level for an individual child is 30 micrograms/100 milliliters. Based on an estimated standard deviation of 1.3, the EPA estimated that a population geometric mean of 15 micrograms/100 milliliters would be necessary in order to place 99.5% of children below the safe blood lead level for an individual child.

Several studies have attempted to establish the major source - air, dust, or soil lead - which accounts for increased lead absorption near smelters. There are conflicting results for different sites. Yankel et al. (1977) concluded that the air lead level was the strongest factor contributing to excess lead absorption by children near a primary lead smelter in northern Idaho. Air exposure alone accounted for 55% of the variance in the children's blood lead levels. Air and soil lead together explained 58% of the variance in blood lead. The authors imply, however, that alone soil lead would not greatly influence the probability that a child would have a deleterious blood lead level (>40 micrograms/100 milliliters).

In an earlier study of the same site, Landrigan et al. (1976) drew similar conclusions. However, the authors note that inhalation alone could not account for the disproportionately elevated blood lead levels seen in younger, poorer and more highly oral children. The authors inferred that ingestion, most often inadvertent, of lead particulates deposited by the smelter was a second important pathway of lead absorption.

In contrast to these studies, both Roberts et al. (1974) and Brunekreef et al. (1981) report ingestion of contaminated soil and dusts as the major route of increased intake by children near smelters. Excessive lead absorption was attributed to the combined effects of the high lead contents of housedust, outdoor dust, and soil, and the play habits and poor personal hygiene of children.

A study by Roels et al. (1978) confirms the importance of both air and soil lead as sources of lead exposure. The authors investigated lead absorption by children near a lead smelter before and after remedial action to reduce the air lead level to acceptable levels. Compared with the results of their first investigation, a significant tendency toward normalization of blood lead levels was found in a subgroup of children of 2.5 kilometers from the lead smelter; but, in a subgroup at less than 1 kilometer from the smelter, blood lead levels did not improve after remedial action. Two hypotheses were put forth to explain the lack of significant improvement in the 1 kilometer subgroup: 1) ingestion of highly contaminated dust and soil from their surroundings in the course of everyday activity; and 2) inhalation and ingestion of continuously resuspended contaminated soil and dusts at the breathing height of the children. In either case, the importance of both air, soil, and dust lead is clear.

Epidemiological studies have resulted in only a limited amount of quantitative information on the relationships between environmental lead and blood lead concentration. Largely based on the results of Azar et al. (1975), the U.S. EPA (1977) estimates that each microgram/cubic-meter of lead in air contributes 2 micrograms/100 milliliters to the blood lead level. Snee (1982), however, suggests that an air-lead/blood-lead

ratio of 1.0 and at maximum 1.4 is more realistic based on an analysis of data from an Idaho smelter site (also examined by Landrigan et al. 1976; Yankel et al. 1977; and Walter et al. 1980).

Barltrop (1975) reported an increase of 0.5 micrograms/100 milliliters for every 500 milligrams/kilogram increase in soil lead for soil lead levels in the range from 420 to 3390 milligrams/kilogram and 0.25 micrograms/100 milliliters for every 500 milligrams/kilogram increase in soil lead for soil lead levels in the range from 3390 to 13969 milligrams/kilogram.

Similar results were obtained by Yankel et al. (1977). Blood lead levels were reported to increase 0.3 micrograms/100 milliliters every 500 milligrams/kilogram increase in soil lead for soil lead levels in the range of 500 to 5000 milligrams/kilogram. A substantially steeper relationship between blood-lead and soil-lead was reported by Brunekreef et al. (1981) for soil ranging between 100 and 600 milligrams/kilogram near a secondary lead smelter in the Netherlands. Blood lead levels were shown to increase 6.3 micrograms/100 milliliters for a 500 milligrams/kilogram increase in soil lead. Brunekreef et al. (1981) suggests that the discrepancy may be accounted for by the smaller total uptake of lead by individuals in their study as compared to the groups studied by Barltrop (1975) and Yankel et al. (1977). Angle et al. (1979) have shown that the increase in blood-lead per unit increase of exposure is greater at low levels of total lead uptake than at high levels of total lead uptake.

Socioeconomic factors also appear to contribute to the relationship between the intake of lead and the level of environmental exposure. In addition to the influences of air, dust, and soil lead, Yankel et al. (1977) reported that age of child, dustiness of home (hygiene), and occupational status of parents were important variables influencing the blood lead levels of children near an Idaho smelter.

All the results discussed above were determined using atomic absorption spectrophotometry. None of the references cited presented detailed discussions of the analytical methods used. However, based on the brief statements in several of the references regarding the analytical procedures employed (i.e., acid digestion), it is apparent that total lead concentrations were reported in all cases. This report was prepared under the assumption that all the results were reported as such.

## SECTION 5 - SUMMARY

Lead in air, dust and soil near sources are elevated well above background concentrations, and several orders of magnitude in excess of naturally occurring concentrations estimated to have been present thousands of years ago. There are many sources of environmental lead contamination. On a mass basis, gasoline combustion is by far the most significant, reportedly responsible for greater than 80% of atmospheric lead world-wide. Gasoline combustion is followed by coal combustion, primary lead smelters, waste oil combustion, and secondary lead smelters. Each of these sources contributes approximately 1% of the total atmospheric contamination by lead.

Concentrations generally exhibit an exponential decline with distance from the source. This is the case with lead contamination from gasoline combustion (i.e., surface soil lead concentration decreases exponentially as the distance from the roadside increases), lead-based paint (i.e., surface soil lead concentration decreases exponentially as the distance from the house increases), and lead smelting facilities (i.e., surface soil lead concentration decreases exponentially as the distance from the smelter increases).

Epidemiological studies confirm that people residing in the vicinity of sources have, on the average, an increased body burden of lead. Because of their physiological susceptibility, the burden carried by children, in particular, may be sufficient to exert toxic effects. The results indicate that air, dust, and soil lead all contribute strongly to increased body burden of lead in children. Socioeconomic factors (e.g.

home hygiene and occupational status of parents) also appear to influence the amount of lead absorbed by children living near sources.

Soils retain lead strongly in their upper few centimeters and are the major sink for pollutant lead. Aeolian and fluvial action are major mechanisms of lead dispersion. Field studies indicate that lead particulates dispersed by these mechanisms are the major form of lead in watersheds adjacent to lead smelters. The results of chemical speciation analyses indicate that particulate lead, not lead precipitates, are the solution controlling solid phase.

Prepared by:

Bryant Browne  
Douglas Crawford

TABLE 1  
ESTIMATED ATMOSPHERIC LEAD EMISSIONS FOR THE  
UNITED STATES, 1981, AND THE WORLD, 1979 (U.S. EPA, 1984)

<u>Source Category</u>	<u>Annual (1981) U.S. Emissions (tons/yr)</u>	<u>Percentage of U.S. Total Emissions</u>	<u>Annual (1979) Global Emissions (tons/year)</u>
Gasoline Combustion	61,000	91.4%	273,000
Waste Oil Combustion	830	1.2	8,900
Solid Waste Disposal	319	0.5	
Coal Combustion	950	1.4	14,000
Oil Combustion	226	0.3	6,000
Wood Combustion	--	--	4,500
Gray Iron Production	295	0.5	50,000
Iron and Steel Production	533	0.8	
Secondary Lead Smelting	631	0.9	770
Primary Copper Smelting	30	0.1	27,000
Ore Crushing and Grinding	326	0.5	8,200
Primary Lead Smelting	921	1.4	31,000
Other Metallurgical	54	0.1	
Zn Smelting			16,000
Ni Smelting			2,500
Lead Alkyl Manufacture	245	0.4	
Type Metal	85	0.1	7,400
Portland Cement Production	71	0.1	
Miscellaneous	233	0.3	5,900
Total	66,749 <sup>a</sup>	100%	449,170

<sup>a</sup> Inventory does not include emissions from exhausting workroom air, burning of lead-painted surfaces, welding of lead-painted steel structures, or weathering of painted surfaces.

Source: For U.S. emissions, Battye (1983), for global emissions, Nriagu (1979).

**TABLE 2**  
**LEAD DUST ON AND NEAR HEAVILY TRAVELED ROADWAYS (U.S. EPA, 1984)**

<u>Sampling Site</u>	<u>Concentration µg Pb/g</u>	<u>Reference</u>
Washington, DC: Busy Intersection Many Sites	13,000 4,000 - 8,000	Fritsch and Prival (1972)
Chicago: Near Expressway	6,600	
Philadelphia: Near Expressway	3,000 - 8,000	Kennedy (1973)
Brooklyn: Near Expressway	900 - 4,900	Lombardo (1973)
New York City: Near Expressway	2,000	Pinkerton et al (1973)
Detroit: Street Dust	970 - 1,200	Ter Haar and Aronow (1974)
Philadelphia: Gutter (Low Pressure)	1,500 210 - 2,600	Shapiro et al (1973)
Gutter (High Pressure)	3,300 280 - 8,200	Shapiro et al (1973)
Miscellaneous U.S. Cities: Highways and Tunnels	10,000 - 20,000	Buckley et al (1973)
Netherlands: Heavily Traveled Roads	5,000	Rameau (1973)

**TABLE 3**  
**LEAD CONCENTRATIONS IN STREET DUST IN LANCASTER, ENGLAND (U.S. EPA, 1984)**

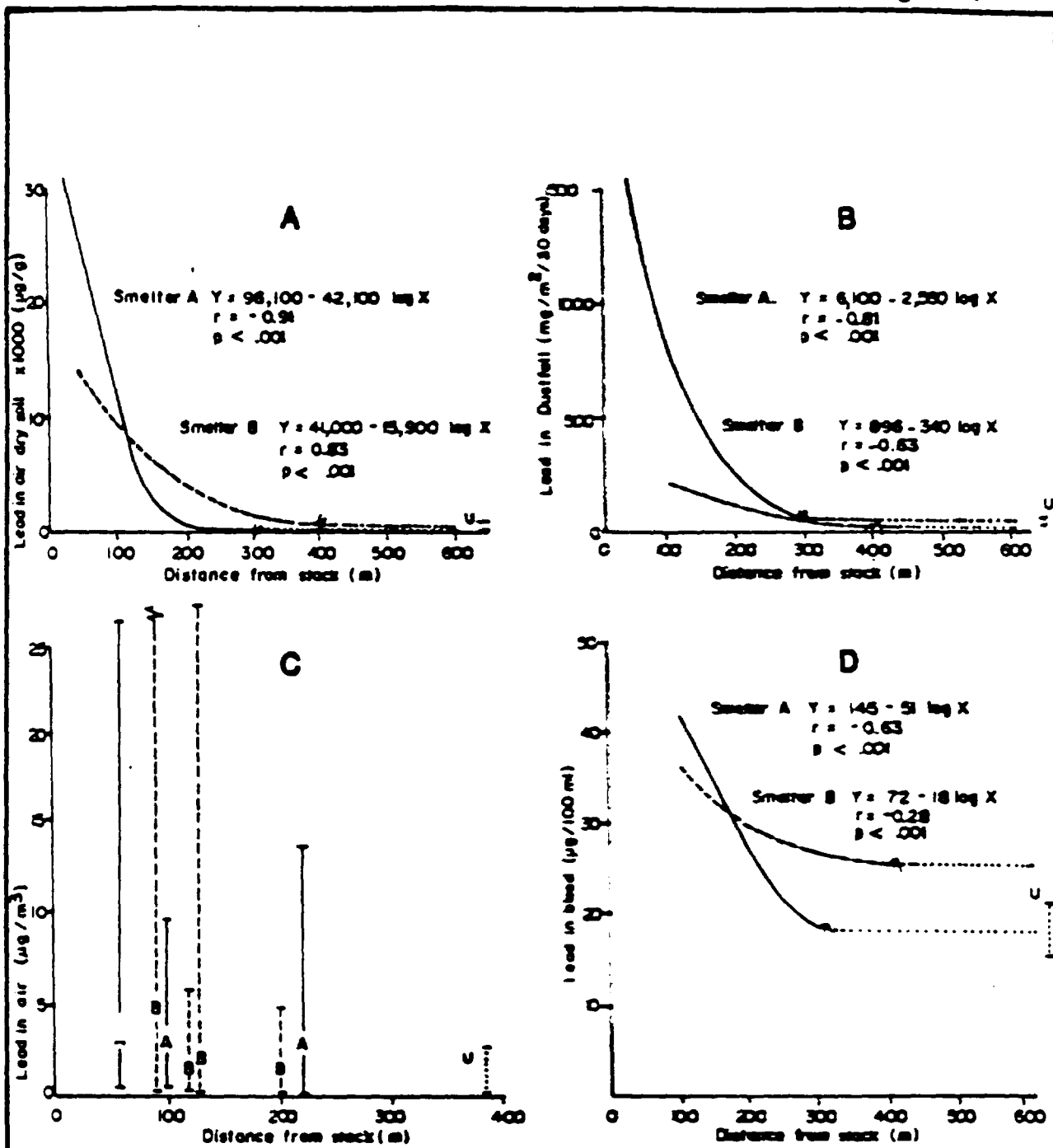
<u>Site</u>	<u>No. of Samples</u>	<u>Range of Concentrations</u>	<u>Mean</u>	<u>Standard Deviation</u>
Car Parks	4	39,700 - 51,900	46,300	5,900
	16	950 - 15,000	4,560	3,700
Garage Forecourts	2	44,100 - 48,900	46,500	--
	7	1,370 - 4,480	2,310	1,150
Town Centre Streets	13	840 - 4,530	2,130	960
Main Roads	19	740 - 4,880	1,890	1,030
Residential Areas	7	620 - 1,240	850	230
Rural Roads	4	410 - 870	570	210

Source: Harrison (1979)

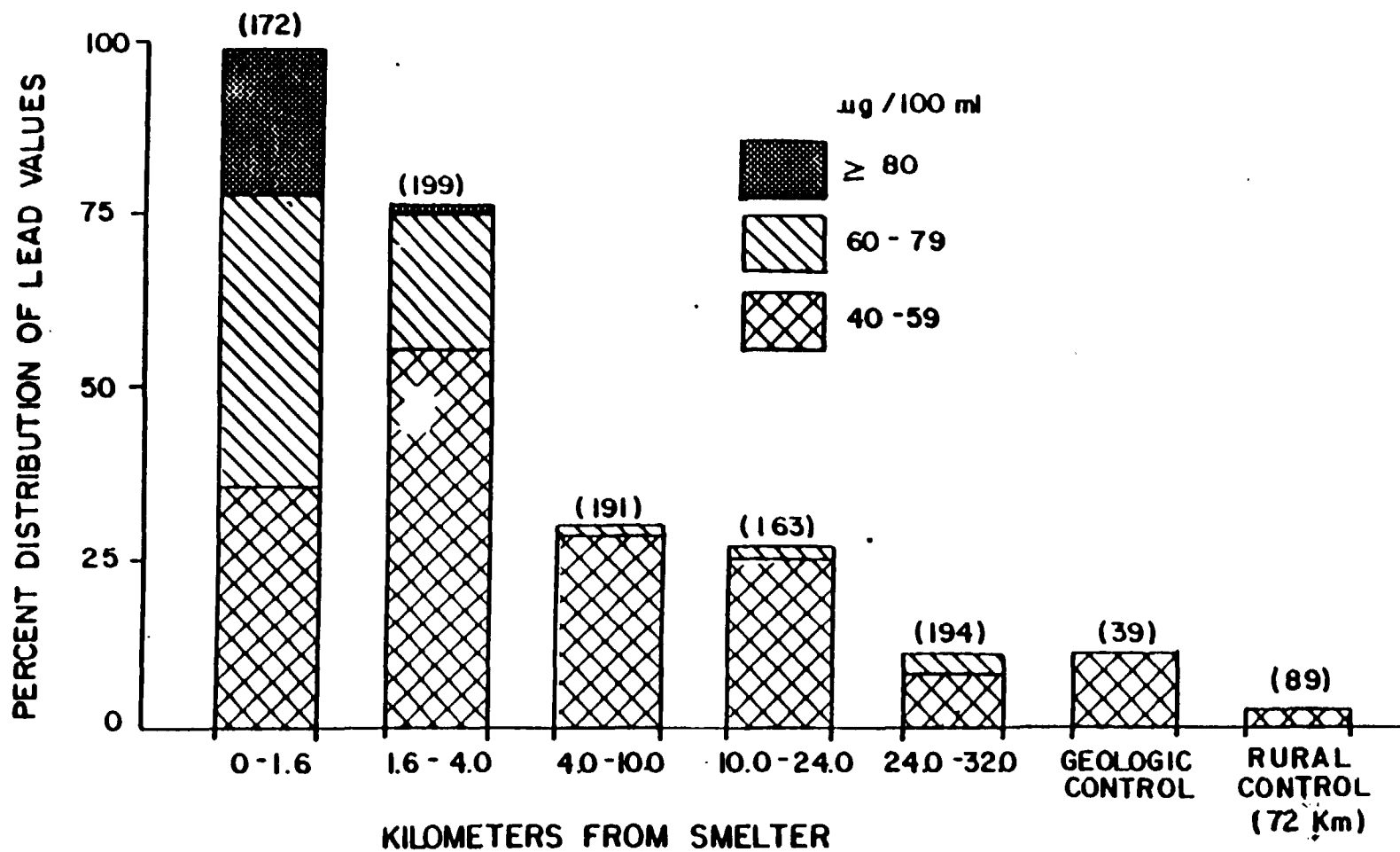
TABLE 4  
LEAD DUST IN RESIDENTIAL AREAS (U.S. EPA, 1984)

<u>Sampling Site</u>	<u>Concentration μg Pb/g</u>	<u>Reference</u>
Philadelphia:		
Classroom	2,000	
Playground	3,000	
Window Frames	1,750	Shapiro et al (1973)
Boston and New York:		
House Dust	1,000 - 2,000	Needleman and Scanlon (1973)
Brattleboro, VT:		
In Home	500 - 900	Darrow and Schroeder (1974)
New York City:		
Middle Class Residential	610 - 740	Pinkerton et al (1973)
Philadelphia:		
Urban Industrial	3,900 930 - 16,000	Needleman et al (1974)
Residential	610 290 - 1,000	Needleman et al (1974)
Suburban	830 280 - 1,500	Needleman et al (1974)
Derbyshire, England:		
Low Soil Lead Area	520 130 - 3,000	Barltrop et al (1975)
High Soil Lead Area	4,900 1,050 - 28,000	Barltrop et al (1975)

Figure 1



LEAD CONCENTRATION AS A FUNCTION OF DISTANCE  
 FROM A SMELTER (ROBERTS, et al, 1974)



**BLOOD LEAD CONCENTRATION AS A FUNCTION OF DISTANCE FROM A LEAD SMELTER IN IDAHO  
(LANDRIGAN, et al, 1975)**

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EXHIBIT A



FISHER RD. EAST SYRACUSE, N.Y. 13207  
TELEPHONE AREA CODE 315 437-1429

May 7, 1987

O'Brien and Gere Engineers, Inc.  
1304 Buckley Road  
Syracuse, New York 13221

Attention: Mr. Douglas M. Crawford  
Project Engineer

Re: L-87004  
Laboratory Testing  
NL Granite City  
File #2844.012.517

Gentlemen:

Enclosed are the results of Sieve and Hydrometer Analyses, and Atterberg Limits performed at your request on soil samples delivered to our office from and for the above project.

Thank you for this opportunity to work with you.

Very truly yours,

PARRATT - WOLFF, INC.

Donald P. Blasland, CET  
Laboratory Manager  
DPB/Inc  
encs:

L-87004  
Laboratory Testing  
NL Granite City



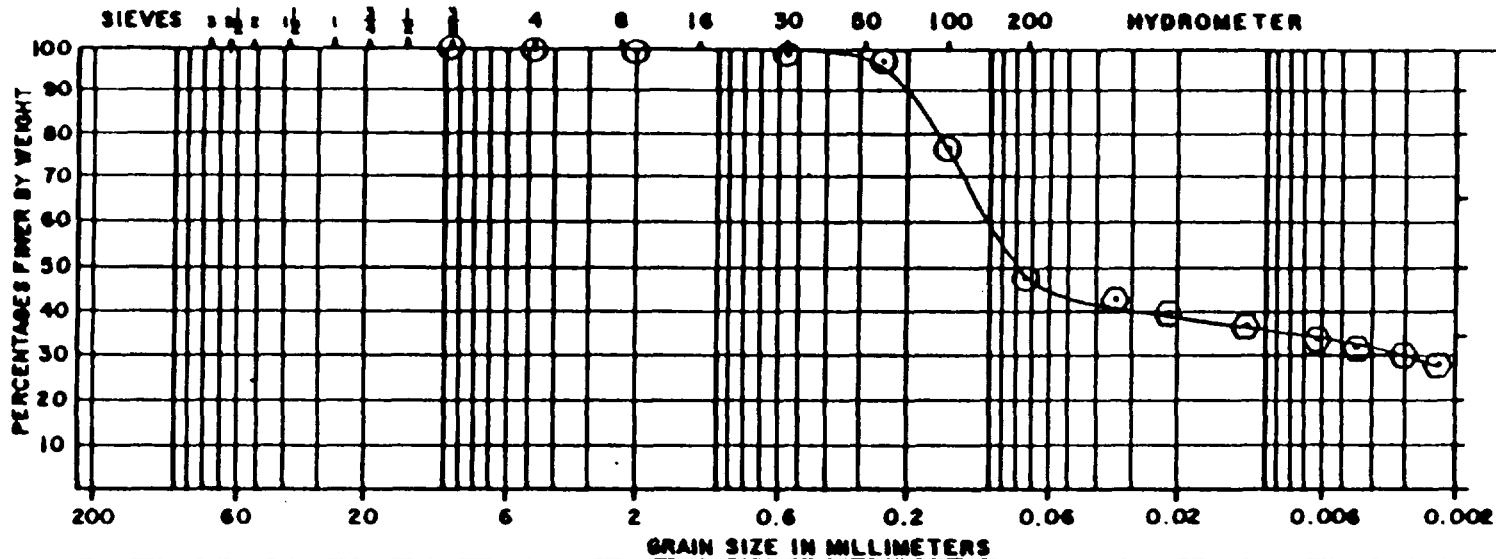
TABLE I  
ATTERBERG LIMITS

<u>Sample</u>	<u>Plastic Limit</u>	<u>Liquid Limit</u>	<u>Plasticity Index</u>
A	21	46	25
B	19	45	26
C	20	37	17

L-87004  
Laborato Testing  
NL GRANITE CITY  
TABLE II  
SIEVE ANALYSIS

[illegible]

# GRAIN SIZE ANALYSIS



BOULDERS COBBLES		GRAVEL			SAND			SILT-CLAY SOIL	
C	M	F	C	M	F	OPENING		SIEVE	
200	76.2	25.4	9.52	2.0	0.85	0.425	0.075	MM.	
9 in.	3 in.	1 in.	3/8 in.	No. 10	30	60	200		

L-87004

Sample A

Laboratory Testing

NL Granite City

File No. 2844.012.517

⊙ Sieve Analysis

⊙ Hydrometer Analysis

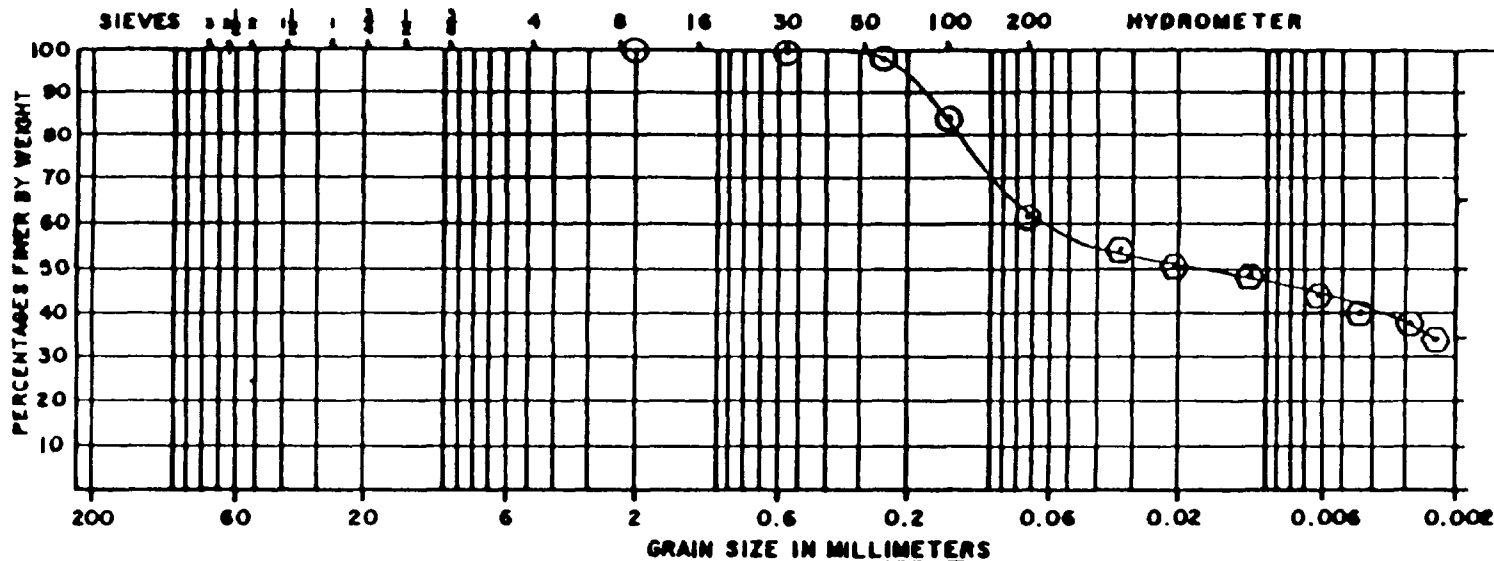
Classification: Unified Soil System ASTM D-2487-

15-ER-80 EAST SYRACUSE, N.Y. 13037  
TELEPHONE AREA CODE 315/437-1428

**paratt**  
**wolff**  
**inc**

JOB NO. L-87004  
REPORT NO. 1

# GRAIN SIZE ANALYSIS



BOULDERS COBBLES		GRAVEL			SAND			SILT - CLAY SOIL	
C	M	F	C	M	F				
228	76.2	25.4	9.52	2.0	0.85	0.25	0.074	MM.	OPENING
9 in.	3 in.	1 in.	3/8 in.	No. 10	30	60	200		SIEVE

L-87004

Sample B

Laboratory Testing  
NL Granite City  
File No. 2844.012.517

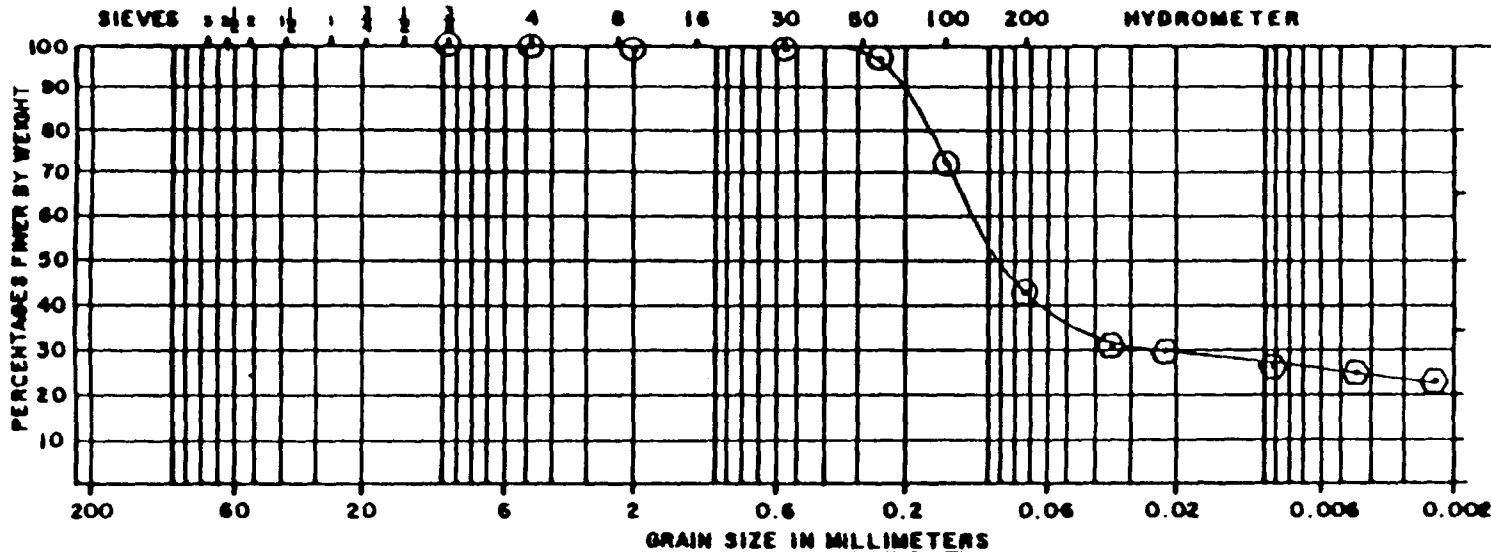
- ⊙ Sieve Analysis
- ⊙ Hydrometer Analysis

Classification: Unified Soil System - ASTM D-2487-

**parmatte**  
**wolff**  
INC.  
715 E. 80. EAST STREET, N.Y. 10017  
TELEPHONE AREA CODE 212/437 1429

JOB NO. L-87004  
REPORT NO. 2

# GRAIN SIZE ANALYSIS



BOULDERS COBBLES		GRAVEL			SAND			SILT-CLAY SOIL	
C	M	F	C	M	F	SILT-CLAY SOIL			
228	76.2	25.4	9.52	2.0	0.59	0.25	0.074	MM.	OPENING
9 in.	3 in.	1 in.	3/8 in.	No. 10	30	60	200		SIEVE

L-87004

Sample C

Laboratory Testing

NL Granite City

File No. 2844.012.517

⊙ Sieve Analysis

⊙ Hydrometer Analysis

Classification: Unified Soil System: ASTM D-2487-

151, 151 RD. EAST SYRACUSE, N.Y. 13057  
TELEPHONE AREA CODE 315/437-1479

**parrett**  
**wolff inc**

JOB NO. L-87004  
REPORT NO. 3

TABLE 2.16 UNIFIED SOIL CLASSIFICATION SYSTEM. (ASTM D-2487)

Major Divisions		Group Symbols	Typical Names		Laboratory Classification Criteria													
<b>Coarse-grained soils</b> (More than half of material is larger than No. 200 sieve size)					<b>Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:</b>  Less than 5 per cent More than 12 per cent 5 to 12 per cent													
									<b>Gravels</b> (More than half of coarse fraction is larger than No. 4 sieve size)		Clean gravels (Little or no fines)		$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3					
											Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW					
									<b>Gravels with fines</b> (Appreciable amount of fines)		GM <sup>a</sup>	d	Silty gravels, gravel-sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4		Above "A" line with P.I. between 4 and 7 are <i>borderline</i> cases requiring use of dual symbols		
											GC	u		Clayey gravels, gravel-sand-clay mixtures	Atterberg limits below "A" line with P.I. greater than 7			
									<b>Sands</b> (More than half of coarse fraction is smaller than No. 4 sieve size)		<b>Clean sands</b> (Little or no fines)		SW	Well-graded sands, gravelly sands, little or no fines			$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
													SP	Poorly graded sands, gravelly sands, little or no fines				Not meeting all gradation requirements for SW
											<b>Sands with fines</b> (Appreciable amount of fines)		SM <sup>a</sup>	d	Silty sands, sand-silt mixtures	Atterberg limits above "A" line or P.I. less than 4		Limits plotting in hatched zone with P.I. between 4 and 7 are <i>borderline</i> cases requiring use of dual symbols
													SC	u		Clayey sands, sand-clay mixtures	Atterberg limits above "A" line with P.I. greater than 7	
									<b>Fine-grained soils</b> (More than half material is smaller than No. 200 sieve)					<b>Silts and clays</b> (Liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity	
CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays																	
OL	Organic silts and organic silty clays of low plasticity																	
<b>Silts and clays</b> (Liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts															
		CH	Inorganic clays of high plasticity, fat clays															
		OH	Organic clays of medium to high plasticity, organic silts															
<b>Highly organic soils</b>		Pt	Peat and other highly organic soils															

<sup>a</sup>Division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is based on Atterberg limits; suffix d used when L.L. is 28 or less and the P.I. is 6 or less; the suffix u used when L.L. is greater than 28.

<sup>b</sup>Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols. For example: GW-GC, well-graded gravel-sand mixture with clay binder.

soils into coarse-grained (having more than 50 percent retained on the No. 200 sieve) and fine-grained (more than 50 percent passing through this sieve). The coarse-grained materials are called gravels (G) if more than 50 percent of the coarse fraction is retained on the No. 4 sieve, and sands (S) if more than 50 percent of this fraction lies between

the No. 40 and No. 200 sieve. The designations G and S are supplemented by the letters W, P, M, and C for well graded, poorly graded, and silt- (Mo) and clay-containing materials, respectively. The soils that have more than 50 percent of silt-clay component (-200 sieve fraction) are subdivided into silts (M) and clays (C) depending on their liquid limit-

From: Winterkorn, H.F. and H.-Y. Fang, 1975. Foundation Engineering Handbook. New York: Van Nostrand Reinhold Co.

### 3:3 Permeability of Soil and Rock Formations

The range in permeability of natural soils is even greater than the range in grain size. Table 3:1 can be used as a standard for describing permeability and as a guide for rough estimates.

TABLE 3:1 / RELATIVE VALUES OF PERMEABILITY  
(After Terzaghi and Peck)<sup>3,6</sup>

Relative Permeability	Values of $k$ (mm/sec) <sup>a</sup>	Typical Formation
Very permeable	1	Coarse gravel, open-jointed rock
Medium permeability	$1 \times 10^{-2}$	Sand, fine sand
Low permeability	$1 \times 10^{-3} - 1 \times 10^{-4}$	Silty sand, dirty sand
Very low permeability	$1 \times 10^{-4} - 1 \times 10^{-6}$	Silt, fine sandstone
Impervious	Less than $1 \times 10^{-6}$	Clay, mudstone without joints

<sup>a</sup>To convert to feet per minute, multiply above values by 0.2.

Permeability is sometimes expressed in other ways. The *Lugeon* unit is approximately  $1 \times 10^{-4}$  mm/sec. It is measured by pumping into a hole drilled in the pervious formation. The *transmissivity* of a confined aquifer of thickness  $H$  is  $kH$ . It is computed from well-pumping tests (Section 3.6 and Chapter 7) in which  $H$  the aquifer thickness, has not been measured.

**VARIATION OF  $k$  IN A REAL FORMATION** / In most soils and rocks the value of  $k$  depends on the direction in which the water is traveling. The  $k$  in the direction parallel to the stratification or planes of foliation is usually from 2 to 30 times that in the direction perpendicular to the bedding or foliation because of the layers with relatively low permeabilities. In soil deposits with erratic lenses of either coarse, pervious materials or fine impervious materials, the permeability varies greatly from point to point and is extremely difficult to determine.

Soils in which there is an orientation of flaky or slablike particles exhibit higher permeabilities parallel to the aligned faces than perpendicular to them. Similar *anisotropic permeability* is typical of some compacted soils.

In soils of low permeability and in most rocks, the permeability of the mass is governed by the cracks and fissures. The effective permeability will be far greater than that of the intact material between the cracks. On the other hand, cemented seams within a generally pervious formation will make the effective permeability across the seams very low. Because of anisotropy and nonhomogeneous defects, a large number of laboratory tests with flow in several directions is necessary for realistic values for the permeability coefficient.

Laboratory test results of fine-grained soils are often unrealistic because the gradients necessary to produce measurable flow are sometimes

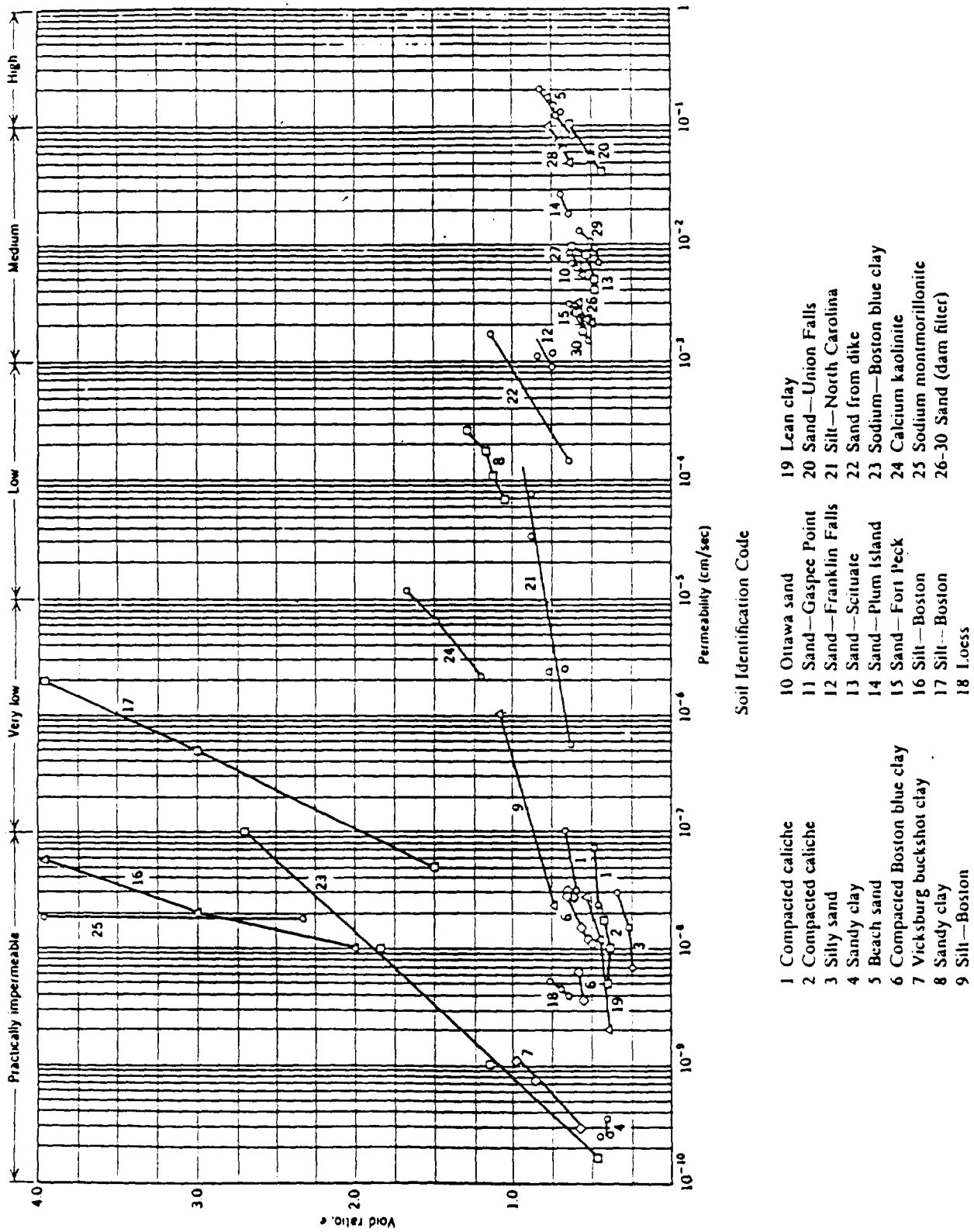


Fig. 19.5 Permeability test data.

From: Lambe, W.T. and R.V. Whitman, 1969. Soil Mechanics. New York: John Wiley & Sons.

in which

- $k$  = the Darcy coefficient of permeability  
 $D_p$  = some effective particle diameter  
 $\gamma$  = unit weight of permeant  
 $\mu$  = viscosity of permeant  
 $e$  = void ratio  
 $C$  = shape factor

The following is an expression for the permeability of porous media, known as the *Kozeny-Carman equation* since it was proposed by Kozeny and improved by Carman:

$$k = \frac{1}{k_0} \frac{\gamma}{S^2 \mu} \frac{e^3}{(1+e)} \quad (19.5)$$

in which

- $k_0$  = factor depending on pore shape and ratio of length of actual flow path to soil bed thickness  
 $S$  = specific surface area

Since  $D_p$  is defined as the diameter of particle having a specific surface of  $S$ , Eq. 19.4 can be considered a simplification of the Kozeny-Carman equation.

Table 19.1 Coefficient of Permeability of Common Natural Soil Formations

Formation	Value of $k$ (cm/sec)
River deposits	
Rhone at Genissiat	Up to 0.40
Small streams, eastern Alps	0.02–0.16
Missouri	0.02–0.20
Mississippi	0.02–0.12
Glacial deposits	
Outwash plains	0.05–2.00
Esker, Westfield, Mass.	0.01–0.13
Delta, Chicopee, Mass.	0.0001–0.015
Till	Less than 0.0001
Wind deposits	
Dune sand	0.1–0.3
Loess	0.001 $\pm$
Loess loam	0.0001 $\pm$
Lacustrine and marine offshore deposits	
Very fine uniform sand, $U^* = 5-2$	0.0001–0.0064
Bull's liver, Sixth Ave., N.Y., $U = 5-2$	0.0001–0.0050
Bull's liver, Brooklyn, $U = 5$	0.00001–0.0001
Clay	Less than 0.0000001

\*  $U$  = uniformity coefficient.

From Terzaghi and Peck, 1967.

From: Lambe, W.T. and R.V. Whitman, 1969. *Soil Mechanics*. New York: John Wiley & Sons.

Table 19.2 Classification of Soils According to Their Coefficients of Permeability

Degree of Permeability	Value of $k$ (cm/sec)
High	Over $10^{-1}$
Medium	$10^{-1}$ – $10^{-3}$
Low	$10^{-3}$ – $10^{-5}$
Very low	$10^{-5}$ – $10^{-7}$
Practically impermeable	Less than $10^{-7}$

From Terzaghi and Peck, 1967.

Equation 19.4 or 19.5 aids considerably in the following examination of the variables affecting permeability. In this examination those characteristics related to the permeant are considered first and then those related to the soil composition are treated.

#### Permeant

Equations 19.4 and 19.5 show that both the viscosity and the unit weight of the permeant influence the value of permeability. These two permeant characteristics can be eliminated as variables by defining another permeability, the *specific* or *absolute* permeability, as:

$$K = \frac{k\mu}{\gamma} \quad (19.6)$$

Since  $k$  is in units of velocity,  $K$  is in units of length<sup>2</sup>; e.g., if  $k$  is in cm/sec, the corresponding unit for  $K$  is cm<sup>2</sup>.  $K$  is also expressed in terms of darcys; 1 darcy =  $0.987 \times 10^{-8}$  cm<sup>2</sup>. For water at 20°C, the following two equations permit one to convert  $k$  in cm/sec to  $K$  in cm<sup>2</sup> or in darcys:

$$K \text{ in cm}^2 = k \text{ in cm/sec} \times 1.02 \times 10^{-3} \quad (19.7)$$

$$K \text{ in darcys} = k \text{ in cm/sec} \times 1.035 \times 10^3 \quad (19.8)$$

Figure 19.6 is a chart for the conversion of permeability values from one set of units to another. (Conversion factors are given in the appendix.)

While viscosity and unit weight are the only variables of the permeant that influence the permeability of pervious soils, other permeant characteristics can have a major influence on the permeability of relatively impervious soils. The magnitude of influence for characteristics other than viscosity and unit weight are illustrated in Fig. 19.7. In this figure values of permeability of saturated kaolinite are plotted for various permeants. The permeability is expressed in terms of the absolute permeability, thus the influences of viscosity and unit weight have been eliminated. The data in Fig. 19.7 show that the nature of the permeant can be very important, with variations of many hundred percent in absolute permeability depending on the actual permeant. The

EXHIBIT B



DATE: November 17, 1982

TO: Division File

FROM: Perry Mann - Southern Region *ECM*

SUBJECT: LPC 11904007 - Madison County - Granite City/Taracorp  
Sample collection and observations at subject site

On November 16, 1982, Diane Spencer and myself visited the subject site in order to split samples collected by Taracorp from the four (4) newly installed wells. We were accompanied by Messrs. J. Wentz and G. Merrit, along with an unidentified employee, of Taracorp.

Samples were collected by utilizing a diaphragm-type hand pump, which was primed using "tap" water. The samples were collected after a sufficient volume was pumped to remove the primer water, i.e., when turbid well water was observed being pumped, instead of the clean "tap" water. Agency samples were pumped into bottles which were later the same day transferred to preserved bottles at the Collinsville office. The field apparatus used for filtering was not compatible with the pumping method utilized by Taracorp. Taracorp's samples, according to Mr. Wentz, were to be filtered in their laboratory, on-site.

A copy of the drillers logs for the new wells was forwarded to me by Mr. Wentz. A review of this information (copies of info enclosed) indicates it to be extremely deficient of pertinent geologic data. Subsurface soil samples were collected at only one boring, B-1, in five foot intervals. The data given allows only the most general evaluations of the hydrogeologic conditions at the subject site to be made.

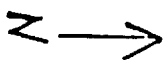
It was observed during the sample collection that the apparent down-gradient (hydrogeologically) wells are quite a distance from Taracorp, i.e. the waste pile. As an example, well B-3 is approximately 200 yards from the waste pile's edge. The placement of these wells causes considerable uncertainty to be placed upon the results from the samples to be indicative of any contamination which may have been caused specifically by the waste pile. Likewise, if the results show no contamination, this would not necessarily indicate no contamination has occurred; contamination may be observable at locations in closer proximity to the source. The distance of the wells to the suspected source is of critical importance, in this case, because of interest specifically in the parameter lead. Lead is relatively insoluble (except under specific chemical conditions) which is a cause for its low mobility character in ground water. A monitoring scheme directed emphatically toward lowly mobile parameters necessitates the placement of monitoring wells in close proximity of the source.

November 17, 1982

Therefore, after receiving the analytic results from these samples, a careful investigation of their validity should be conducted prior to any future collections of samples or installation of additional monitoring wells.

PCM:jlz

cc: Southern Region  
Monte Nienkerk  
Bill Seltzer  
Sherry Otto  
Tom Bierma - DAPC



MH TOP (CENTER OF ALLEY @ 16th STREET)  
420.03'

16th Street  
DELMAR

421.9'  
EDISON

420.8'  
0.61'

417.3'  
0.82'

STATE  
STREET

417.6'  
0.63'

NOT TO SCALE

LOG OF BORING NO. E-1 AT WELL #1

JOB NO. 62-004

**TEST ENGINEERING SERVICE CO.**PHONE: (314) 731-2121 6035 NORTH LINDBERGH BLVD. HAZELWOOD, MO 63044  
ST. LOUIS COUNTY

CLIENT: TARACORP

PROJECT: Observation Wells

DEPTH, FT.	SAMPLE	SAMPLE NO.	BLOWS PER 5' COUNT*	COIL DESCRIPTION	
				DEPTH	TYPE SOIL OR ROCK, COLOR MOISTURE, REMARKS
				5.5	
5	SS	1	2-3-3		SAND & CLAY, Brown & Gray
10	SS	2	1-1-3		SAND & CLAY, Gray, Fine
				16.0	
15	SS	3	3-5-6		" " "
20	SS	4	1-1-2		SANDY SILT, Gray, Fine, Wet
				30.5	
25	SS	5	1-1-2		" " "
30	SS	6	1-1-2		" " "
					Bottom of Boring @ 30.5'
35					
40					

COMPLETION DEPTH: 30.5'

DATE: 10-28-82

DEPTH TO WATER:

DATE:

AS-AUGER SAMPLE

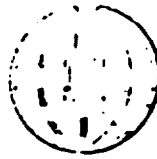
ST-SHELBY TUBE

SS-STANDARD PENETRATION TEST (ASTM D 1586)

REMARKS:

CREW: Lay &amp; Shilton

PLATE



TARACORP INDUSTRIES

Job No. 82-094

P.O. No. 8946

SUMMARY OF OBSERVATION WELL CONSTRUCTION

(Data recorded in feet below existing ground surface)

<u>Well Number</u>	<u>Total Depth</u>	<u>Screen Depth</u>	<u>Filter Horizon</u>	<u>Bentonite Seal</u>	<u>Elevation Top of Steel Casing (USGS)</u>
1	25.0'	15-25	13-25	11-13	421.9'
2	25.0'	15-25	15-25	13-15	417.3'
3	25.0'	15-25	13-25	11-13	417.6'
4	27.0'	17-27	13-27	11-13	420.8'

- NOTE: 1. (USGS) United States Geological Survey (Feet above mean sea level)
2. Elevation control monument = 420.03 top of manhole cover in center of alley at 16th Street across the street from guard house
3. Elevation given = Top of 6"Ø steel monument pipe
4. Accuracy of 11-5-82 elevation survey = 0.05' (error of closure)

LOG OF BORING NO.

# TEST DRILLING SERVICE CO.

**ST. LOUIS COUNTY**

**CLIENT:**

**PROJECT:**

[illegible]

**NOTE: Best Available Copy**

**COMPLETION DEPTH:**

**DEPTH TO WATER:**

DATE: 10.20.82

DATE:

(° ASTM D 1585)

REMARKS:

**CREW:**

**Distribution:** Job File-White  
Driller-Canary  
Client-Pink

# PLATE

**TDS Ca. 102**

LOG OF BORING NO.

# TEST DRILLING SERVICE CO.

**ST. LOUIS COUNTY**

CLIENT: THRA Corp

**PROJECT:**

DEPTH, FT.	SAMPLE	SAMPLE NO.	BLOWS PER 6" COUNT*	SOIL DESCRIPTION	
				DEPTH	TYPE SOIL OR ROCK, COLOR MOISTURE, REMARKS
0					
5	SS	1	2-3	4-5'	GRAV. FINE SAND + CLAY
10	SS	2	1-2	9-11'	GRAV. FINE SAND + CLAY
12	SS	3	3-4	11-12'	GRAV. FINE SAND + CLAY
20	SS	4	1-2	17-20'	GRAV. MED. FINE SAND + CLAY
24	SS	5	1-2	24-25'	GRAV. MED. FINE SAND + CLAY
28	SS	6	1-2	27-30'	GRAV. MED. FINE SAND + CLAY

NOTE: Best Available Copy

**NOTE: Best Available Copy**

**COMPLETION DEPTH:**

**DEPTH TO WATER:**

DATE: 10-29-82

**DATE:**

(° ASTM D 1500)

REMARKS:

CREW: LARRY SHULTZ

**Distribution:** Job File—White  
Driller—Canary  
Client—Pink

# PLATE

**PROJECT:**

DEPTH, FT.	SAMPLE	SAMPLE NO.	BLOWS PER 6" COUNT	SOIL DESCRIPTION	
				DEPTH	TYPE SOIL OR ROCK, COLOR, MOISTURE, REMARKS
0					
5					
10					
15					
20					
25					
<p>NOTE: Best Available Copy</p>					
COMPLETION DEPTH:				DEPTH TO WATER:	
DATE: 10-27-82				DATE:	
<p>(* ASTM D 1586 )</p> <p>REMARKS:</p>					

CREW: LONG SHUTTLE

**Distribution:**    Job File-White  
                         Dryer-Canary  
                         Client-Pink

# PLATE

**TDS Ca 102**

LOG OF BORING NO. 15-2**TEST DRILLING SERVICE CO.**

ST. LOUIS COUNTY

CLIENT: TRIP

PROJECT:

DEPTH, FT.	SAMPLE	SAMPLE NO.	BLOWS PER 8" COUNT	SOIL DESCRIPTION	
				DEPTH	TYPE SOIL OR ROCK, COLOR MOISTURE, REMARKS
0					
5					
10					
15					
20					
25					
30					
35					
40					
45					
50					
55					
60					
65					
70					
75					
80					
85					
90					
95					
100					
105					
110					
115					
120					
125					
130					
135					
140					
145					
150					

NOTE: Best Available Copy

COMPLETION DEPTH:

DEPTH TO WATER:

DATE: 10-20-50

DATE:

(° ASTM D 1586 )

REMARKS:

CREW: RAY & HOLTDistribution: Job File—White  
Driller—Canary  
Client—Pink

PLATE

TDS Co. 102

LOG OF BORING NO.

# TEST DRILLING SERVICE CO.

**ST. LOUIS COUNTY**

CLIENT: TARA CAMP

**PROJECT:**

[illegible]



Illinois Environmental Protection Agency · 2200 Churchill Road, Springfield, IL 62706

cc: FD 1111 084

(217) 782-6761

Refer to: L1190400007--Madison County  
Granite City/Taracorp  
Superfund/Technical Reports

February 10, 1987

RECEIVED

FEB 17 1987

ENVIRONMENTAL  
CONTROL

Mr. Steve Holt  
NL Industries  
Environmental Control Department  
P.O. Box 1090  
Highstown, NJ 08520

Dear Mr. Holt:

Attached are the boring logs for the monitoring wells which were installed on the site by the IEPA. These borings logs are taken from a draft IEPA report "A Land Pollution Assessment of Granite City/Taracorp Industries" September, 1984 which will be sent to you upon finalization.

Useful information about groundwater in the vicinity of the site (i.e. possible effects of withdrawal wells on flow) may be available from Department of Transportation (DOT), Division of Water Resources, Director: Don Vonnohm 217/782-2152.

Should you require any additional information, please contact me at the above number.

Sincerely,

Kenneth M. Miller, Project Manager  
Federal Sites Management Unit  
Remedial Project Management Section  
Division of Land Pollution Control

KMM:kh/c

cc: Bob Cowles, w/o att.  
Brad Bradley, w/att.  
DLPC File, w/att.  
RPMS File  
Author w/o att.



# Illinois Environmental Protection Agency

BORING NO. <b>B-55</b>		WELL NO. <b>G-1055 GISS</b>		GROUND LEVEL ELEV. <b>425.94</b>		PAGE <b>1</b> OF <b>2</b>	
COUNTY <b>Madison</b>		SITE NO. <b>L11904007</b>		DATE <b>7/19/83</b>		ABOVE PACKING <b>silica sand with bentonite</b>	
BORING LOCATION <b>Granite City / Taracorp</b>		DATE <b>7/19/83</b>		DATE <b>7/19/83</b>		ABOVE PACKING <b>Ca bentonite in concrete</b>	
DRILLING EQUIPMENT <b>CME 55 3 1/4 inch I.D. hollow stem augers</b>		DATE <b>9:15A.</b>		DATE <b>4:30P.</b>		SCREEN <b>silica sand</b>	
COMPLETION DEPTH <b>26.5 ft.</b>		BEDROCK DEPTH <b>-</b>		TOP OF CASING <b>428.87 PVC</b>			
WELL CASING <b>2 inch I.D. flush joint threaded schedule 40 PVC</b>		TYPE AND QUANTITY		SAMPLES		PERSONNEL	
SCREEN INTERVAL <b>21-26 ft. PVC #10 slot 2 inch I.D. Flush joint threaded schd. 40</b>		TYPE AND QUANTITY		SAMPLES		PERSONNEL	
ELEV. <b>425.94</b>		DESCRIPTION		DEPTH		REMARKS	
			Dark brown to black <u>sandy Silt</u>		0		
					1		
					2		
			2.5-2.8 Light brown <u>silty Sand</u> , very fine grained, some roots		3	S <sub>1</sub> SS 1.0	3/5
			2.8-3.5 Gray <u>silty Clay</u> with some iron staining, trace roots		4		
			4.0-4.4 Brown <u>silty Clay</u> with trace iron staining		5	S <sub>2</sub> SS 1.0	4/4
420.94			4.4-5.0 Light brown <u>silty Sand</u> , very fine to fine grain, trace roots		6	S <sub>3</sub> SS 0.9	3/2
			5.5-5.8 Light brown <u>Silt</u>		7		
			5.8-6.3 Light brown <u>Sand</u> very fine to fine grain, trace roots, some iron staining, dry		8	S <sub>4</sub> SS 1.5	1/1
			7.0-7.2 Same as above, moist		9	S <sub>5</sub> SS 1.2	4/7
			7.2-8.5 Grayish brown <u>Silt</u> , trace roots, little iron staining, blocky, wet		10		
			8.5-9.0 Same as above		11	S <sub>6</sub> SS 1.5	7/4
			9.0-9.7 Brown <u>silty Sand</u> , very fine to fine grain, moist		12	S <sub>7</sub> SS 1.5	5/5
415.94			9.7-10.0 Gray to brown <u>Sand</u> , fine grain, thinly bedded		13		
			10.0-11.5 Same as above				
			11.5-13.0 Gray to brown <u>Sand</u> fine to medium grain, thinly bedded, moist				



# Illinois Environmental Protection Agency

BORING NO. B-55		WELL NO. G1055 G155		GROUNDLEVEL ELEV.		PAGE 2 OF 2		
COUNTY Madison		SITE NO. L11904007		START DATE FRESH		ANNULUS FILL MATERIAL ABOVE PACKING		
BORING LOCATION Granite City / Taracorp		DRILLING EQUIPMENT SIZE TYPE		START TIME FRESH		PACKING		
COMPLETION DEPTH		BEDROCK DEPTH		TOP OF CASING		SCREEN		
WELL CASING TYPE AND QUANTITY		SAMPLES				PERSONNEL		
SCREEN INTERVAL TYPE AND QUANTITY								
ELEV	DESCRIPTION	DEPTH	Sample No	Sample Type	Sample Recovery Ft	Penetrometer (Strength)	N Value (Blows)	REMARKS
412.94	13-14.5 Same as above	13						
		14	S <sub>8</sub>	SS	1.5		10/16	
410.94	14.5-16 Same as above	15	S <sub>9</sub>	SS	1.5		15/17	
	16.-17.5 Same as above	16						
		17	S <sub>10</sub>	SS	1.3		17/19	
	17.5-19 Same as above	18	S <sub>11</sub>	SS	1.5		19/25	
	19 - 20.5 Same as above	19						
405.94	20.5-20.7 Same as above	20	S <sub>12</sub>	SS	1.5		21/13	
	20.7-21 Gray Clay, hard, moist, iron band at contact with sand at top and bottom	21	S <sub>13</sub>	SS	1.5	0.5	9/11	Penetrometer reading taken from 20.7 to 21 ft.
	21-22 Light brown Sand medium to coarse grain with trace pebbles angular to subangular, moist	22						
	22-22.7 Same as above	23	S <sub>14</sub>	SS	1.4		7/5	← H <sub>2</sub> O
	22.7-23.3 Brown Sand, very coarse grain angular to subangular, wet	24	S <sub>15</sub>	SS	1.2		8/9	Splitspoon Sampled to 26.5 ft;
6.94	23.3-26.5 Brown Sand very fine to fine grain, wet	25						Augered to 26 ft;
		26	S <sub>16</sub>	SS	1.5		10/14	
399.44	Boring complete							



# Illinois Environmental Protection Agency

BORING NO. <b>B-5D</b>		WELL NO. <b>G15D</b>		GROUND LEVEL ELEV. <b>426.05</b>		PAGE <b>1</b> OF <b>1</b>	
COUNTY <b>Madison</b>		SITE NO. <b>L11904007</b>		DATE <b>7/20/83</b>		FRESH <b>7/20/83</b>	
SITE <b>Granite City/Taracorp</b>				ABOVE PACKING <b>Cuttings</b>			
BORING LOCATION <b>NW corner of site along RR tracks</b>				PACKING <b>Concrete with Ca bentonite</b>			
DRILLING EQUIPMENT <b>CME 55 3 1/4 inch I.D. hollow stem auger</b>				START TIME <b>9:00A</b>		FRESH TIME <b>7:15P</b>	
COMPLETION DEPTH <b>41.5 ft</b>		BEDROCK DEPTH <b>—</b>		TOP OF CASING <b>428.99 PVC</b>		SCREEN <b>in situ sand</b>	
WELL CASING <b>2 inch I.D. flush joint threaded schedule 40 PVC</b>				SAMPLES			
SCREEN INTERVAL <b>30.3 - 35.3 ft. PVC #10 slot 2 inch I.D. flush joint threaded schedule 40</b>				PERSONNEL			
ELEV. <b>426.05</b>				1. <b>Sherry Otto</b> 2. <b>Doug Tolan</b> 3. <b>Ken Bosie</b>			
DESCRIPTION				REMARKS			
<p>Brown <u>Sand</u> medium to very coarse grain, wet</p>				<p>Augered from 0-40 ft. with no samples taken; description from cuttings</p>			
<p>384.55</p>				<p>Boring complete</p>			



# Illinois Environmental Protection Agency

BORING NO. B-65		WELL NO. G1065 G16S		GROUNDLEVEL ELEV. 421.12		PAGE 1 OF 2			
COUNTY Madison		SITE NO. L11904007		START DATE 7/21/83		FRESH ABOVE PACKING silica sand with bentonite			
BORING LOCATION Granite City / Taracorp		Casing EQUIPMENT CME 55 3 1/4 inch I.D. hollow stem auger		START TIME 7:50A.		FRESH PACKING concrete with Ca ben-tonite			
COMPLETION DEPTH 22 ft.		BEDROCK DEPTH		TOP OF CASING 424.00 PVC		SCREEN silica sand			
WELL CASING 2 inch I.D. flush joint threaded schedule 40 PVC		TYPE AND QUANTITY		SAMPLES				PERSONNEL	
SCREEN INTERVAL 15.79 to 20.79 ft. PVC #10 slot 2 inch I.D. flush joint threaded schedule 40		TYPE AND QUANTITY		SAMPLES				PERSONNEL	
ELEV 421.12		DESCRIPTION		DEPTH		REMARKS			
		0 - 1.5 Fill material		0					
		1.5 - 5.0 Brown - gray Sand very fine to fine grained, thinly bedded, iron stains		1					
				2		S <sub>1</sub> CS 2.4			
				3					
				4					
416.12		5.0 - 10.0 Gray silty Clay, iron stains, blocky, brown wet silt seam at 8.6, more brown at bottom		5					
				6		S <sub>2</sub>			
				7		CS 4.8			
				8					
				9		S <sub>3</sub>			
				10		1.75			
411.12		10.0 - 10.85 Same as above		10					
		10.85 - 11.0 Brown Sand very fine to fine grain, iron stains		11		S <sub>4</sub> SS 1.5 1.25 3/4			
		11.0 - 11.15 Gray brown silty Clay, iron staining							
		11.15 - 11.5 Gray brown Sand very fine to fine grain		12		S <sub>5</sub> SS 1.5 1.0 3/2			
		11.5 - 11.9 Brown gray silty Clay							
		11.9 - 13.0 Brown gray Sand very fine to fine grain, moist		13					



# Illinois Environmental Protection Agency

BORING NO. <b>B-6S</b>		WELL NO. <b>G1665 G16S</b>		GROUNDLEVEL ELEV.		PAGE <b>2</b>		OF <b>2</b>	
COUNTY <b>Madison</b>		SITE NO. <b>L11904007</b>		DATE		FINISH		ANNULUS FILL MATERIAL	
BORING LOCATION <b>Granite City / Taracorp</b>		START		TIME		FINISH		PACKING	
DRILLING EQUIPMENT		SIZE		TYPE		SCREEN		PERSONNEL	
COMPLETION DEPTH		BEDROCK DEPTH		TOP OF CASING					
WELL CASING		TYPE AND QUANTITY				SAMPLES			
SCREEN INTERVAL		TYPE AND QUANTITY							
ELEV <b>408.12</b>		DESCRIPTION		DEPTH		Sample No.		REMARKS	
		13.0-14.5 <u>Brown Sand</u> very fine to fine grain, iron staining, wet		13		S <sub>6</sub> SS 1.2			
406.12		14.5-16.0 Light gray <u>Clay</u> little iron staining		14		S <sub>7</sub> SS 1.5 1.0			
		16.0-17.5 Same as above; becoming more silty at bottom, sand filled fractures		15		S <sub>8</sub> SS 1.0			
		17.5-18.9 <u>Brown Sand</u> very fine to fine grain, thinly bedded, trace iron staining, wet		16		S <sub>9</sub> SS 1.4		← H <sub>2</sub> O	
		19.5-20.5 Gray brown <u>Sand</u> very fine to fine grain, wet		17		S <sub>10</sub> SS 1.1			
401.12		20.5-22.0 <u>Brown Sand</u> fine to coarse grain subangular to subrounded, poorly sorted, iron staining, wet		18		S <sub>11</sub> SS 1.4			
		399.12		19					
		Boring complete		20					
				21					
				22					



Boring No. B-6D		Well No. G106D G16D		Ground Level Elev. 421.10		Page 1 of 2	
County Madison		Site No. L11904007		Date 7/25/83		Above Packing silica sand with bentonite	
Boring Location West side of Taracorp along RR tracks		Drilling Equipment CME 55 3 1/4 inch I.D. hollow stem auger		Start Time 8:55A		Finish Time 2:00P.	
Complete On Depth 35.0 ft.		Bedrock Depth -		Top of Casing 423.93 PVC		Packing concrete with Ca bentonite	
Well Casing 2 inch I.D. flush joint threaded schedule 40 PVC		Type and Quantity		Screen in situ sand		Personnel L. Sherry Otto, D. Doug Tolan, M. Ken Bosie	
Screen Interval 29.91 - 34.91 ft. PVC #10 slot 2 inch I.D. flush joint threaded Schd. 40		Type and Quantity		Sample No.		Sample Type	
Elev. 421.10		Description		Depth		Sample Recovery %	
						Penetration (lb/inch)	
						N Value (blows)	
						Remarks	
401.10	19.5 - 20.5 Gray brown Sand very fine to fine grain, wet	19					
	20.5 - 21.0 Brown Sand fine to medium grain, wet	20					
	21.0 - 21.7 Brown Sand very fine to very coarse grain, poorly sorted, sub-angular	21					
		22		CS 23			
		23		S <sub>12</sub>			
		24					
396.10	24.5 - 27.0 Same as above	25					
		26		S <sub>13</sub> CS 27			
		27					
	27.0 - 30.0 Same as above	28					
		29		S <sub>14</sub> CS 15			
391.10		30					



# Illinois Environmental Protection Agency

BORING NO.		WELL NO.		GROUNDLEVEL ELEV.		PAGE	
B-6D		G106D G16D				2 2	
COUNTY		SITE NO.		DATE		ANNUAL FILL MATERIAL	
Madison		L11904007				ABOVE PACKING	
BORING LOCATION				START		FINISH	
Granite City / Taracorp							
DRILLING EQUIPMENT		SIZE		TYPE		PACKING	
COMPLETION DEPTH		BEDROCK DEPTH		TOP OF CASING		SCREEN	
WELL CASING		TYPE AND QUANTITY		SAMPLES			
SCREEN INTERVAL		TYPE AND QUANTITY		PERSONNEL			
ELEV		DESCRIPTION		DEPTH		REMARKS	
391.10				30			
		30.0 - 33.0 Same as above; becoming very coarse at bottom		31			
				32		S <sub>15</sub> CS 3.4	
				33			
		33.0 - 35.0 Same as above		34		S <sub>16</sub> CS 0.1	
				35			
388.10							
		Boring complete					
386.10							



# Illinois Environmental Protection Agency

BORING NO. B-75		WELL NO. G1075 G175		GROUNDLEVEL ELEV. 419.06		PAGE 1 OF 2	
COUNTY Madison		SITE NO. L11904007		DATE 7/26/83		FRESH 7/26/83	
SITE Granite City / Taracorp				START TIME 10:00A.		FINISH TIME 1:00P.	
BORING LOCATION West side of Taracorp along RR tracks				ABOVE PACKING silica sand and bentonite		PACKING concrete with Ca bentonite	
DRILLING EQUIPMENT CME 55 3 1/4 inch I.D. hollow stem auger				SCREEN silica sand			
COMPLETION DEPTH 22 ft.		BEDROCK DEPTH —		TOP OF CASING 421.07 PVC			
WELL CASING 2 inch I.D. flush joint threaded schedule 40 PVC				SAMPLES			
SCREEN INTERVAL 17.46 - 22.46 ft. PVC #10 slot 2 inch I.D. flush joint threaded schedule 40				PERSONNEL			
ELEV. 419.06				L. Sherry Otto D. Doug Tolan H. Ken Bosie			
DESCRIPTION				REMARKS			
0 - 2.5 Fill material				Augered to 2.5ft with no samples taken			
2.5 - 3.5 Same as above							
3.5 - 5.0 Light brown Sand very fine to fine grain, thinly bedded, dry							
5.5 - 6.3 Same as above							
6.3 - 6.6 Light brown Silt							
6.6 - 7.2 Light brown Sand very fine to fine grain, thinly bedded, dry							
7.2 - 8.7 Brown clayey Silt, micaceous, thinly bedded, some roots, iron stains along beds, moist							
8.7 - 10.0 Gray - brown Sand very fine to fine grain, thinly bedded, some roots, iron stains along beds, wet							
10.0 - 10.7 Same as above							
10.7 - 11.1 Brown clayey Silt, iron staining							
11.1 - 11.5 Gray Sand very fine to fine grain, thinly bedded, iron stains along beds, trace roots							
11.5 - 13.0 Gray Sand very fine to fine grain, micaceous, thinly bedded with black streaks along beds, wet							



# Illinois Environmental Protection Agency

BORING NO. B-7S		WELL NO. G107S G17S		GROUNDLEVEL ELEV.		PAGE 2 OF 2			
COUNTY Madison		SITE NO. L11904007		DATE		ABOVE PACKING			
SITE Granite City/Taracorp				START		FINISH			
BORING LOCATION				START		FINISH			
DRILLING EQUIPMENT		SIZE		TYPE		PACKING			
COMPLETION DEPTH		BEDROCK DEPTH		TOP OF CASING		SCREEN			
WELL CASING		TYPE AND QUANTITY		SAMPLES				PERSONNEL	
SCREEN INTERVAL		TYPE AND QUANTITY		L. D. H.				REMARKS	
ELEV.	DESCRIPTION	DEPTH	Sample No.	Sample Type	Sample Recovery %	Penetration (lb/inch)	N Value (blows)		
406.06	13.0 - 14.5 Same as above	13							
		14		SS	1.2		$\frac{2}{3}$		
404.06	14.5 - 16.0 Gray Sand very fine to fine grain, thinly bedded, iron stains along beds, roots, wet	15	S <sub>7</sub>	SS	1.4		$\frac{2}{1}$		
	16.0 - 17.5 Same as above, although more silty	16							
		17	S <sub>8</sub>	SS	1.5		$\frac{2}{2}$		
	17.5 - 19.0 Gray silty Sand very fine to fine grain, thinly bedded, iron stains, black streaks along beds, wet	18	S <sub>9</sub>	SS	1.5		$\frac{2}{4}$		
	19.0 - 20.5 Gray Sand very fine to fine grain, thinly bedded, black streaks along beds, iron stains, wet	19							
399.06		20	S <sub>10</sub>	SS	1.3		$\frac{5}{5}$		
	20.5 - 21.0 Same as above	21							
	21.0 - 22.0 Green gray Sand very fine to fine grain, thinly bedded, black streaks along beds, wet	21	S <sub>11</sub>	SS	1.5		$\frac{5}{6}$		
397.06	Boring complete	22							



# Illinois Environmental Protection Agency

BORING NO. B-7D		WELL NO. G107D G17D		GROUNDLEVEL ELEV. 419.07		PAGE 1 OF 2	
COUNTY Madison		SITE NO. L11904007		DATE START 7/25/83 FINISH 7/26/83		ABOVE PACKING Silica sand and bentonite	
SITENAME Granite City/Taracorp		BORING LOCATION West side of Taracorp along RR tracks		TIME START 3:45P FINISH 4:00P		PACKING Concrete with Ca bentonite	
DRILLING EQUIPMENT CME 55 3 1/4 inch I.D. hollow stem auger		SIZE 42197 PVC		SCREEN in situ sand			
COMPLETION DEPTH 35 ft		BEDROCK DEPTH		TOP OF CASING			
WELL CASING 2 inch I.D. flush joint threaded schedule 40 PVC		TYPE AND QUANTITY		SAMPLES		PERSONNEL	
SCREEN INTERVAL 30.44 - 35.44 ft PVC #10 slot 2 inch I.D. flush joint threaded schd. 40		TYPE AND QUANTITY				PERSONNEL	
ELEV 419.02		DESCRIPTION		DEPTH		REMARKS	
399.02	20.0-25.0 Gray Sand very fine to fine grain; thinly bedded with black streaks along beds, micaceous, some roots, wet	20					Augered To 20 ft. with no samples taken
		21					
		22			CS		
		23					
		24					
394.02	25.0-30.0 Same as above	25					
		26					
		27					
		28		S <sub>12</sub>	CS 2.8		
		29					
389.02	30.0-31.7 Gray silty Sand very fine to fine grain; black streaks along beds, wet	30					
		31					
		32		S <sub>13</sub>	CS 4.0		
		33					



# Illinois Environmental Protection Agency

BORING NO.		WELL NO.		GROUNDLEVEL ELEV.		PAGE	
COUNTY		SITE		DATE		OF	
B-7D		G107D G17D				2 2	
Madison				L11904007		ABOVE PACKING	
Granite City / Taracorp						PACKING	
BORING LOCATION				START		FINISH	
DRILLING EQUIPMENT				START		FINISH	
COMPLETION DEPTH				SCREEN			
WELL CASING				TYPE AND QUANTITY		SAMPLES	
SCREEN INTERVAL				TYPE AND QUANTITY		PERSONNEL	
ELEV				DEPTH		REMARKS	
386.02				33			
33.8 - 34.2 Gray sandy Silt black streaks a-long beds, wet.				34		CS	
34.2 - 35.0 Gray Sand very fine to fine grain, wet.				35		S14	
Boring complete							



# Illinois Environmental Protection Agency

BORING NO.		WELL NO.		GROUNDLEVEL ELEV.		PAGE	
COUNTY		SITE NO.		DATE		OF	
B-8S		G1085 G18S		419.94		1 2	
SITE				START DATE		FRESH	
Madison				7/27/83		7/27/83	
BORING LOCATION				START DATE		FRESH	
Granite City / Taracorp				7:00A.		3:00P.	
DRILLING EQUIPMENT				ABOVE PACKING		ANNUOUS FILL MATERIAL	
CME 55 3 1/4 inch I.D. hollow stem auger				concrete with Ca bentonite		silica sand and ben tonite	
COMPLETION DEPTH		BEDROCK DEPTH		TOP OF CASING		SCREEN	
22 ft.		-		422.88 PVC		in situ sand	
WELL CASING				SAMPLES			
2 inch I.D. flush joint threaded schedule 40 PVC				PERSONNEL			
SCREEN INTERVAL				L. Sherry Otto			
15.4-20.4 ft. PVC #10 slot 2 inch I.D. flush joint threaded schd. 40				D. Doug Tolan			
ELEV				H. Ken Bosie			
419.94				REMARKS			
DESCRIPTION				DEPTH			
0.0-2.5 Fill material				0			
2.5-5.0 Same as above				1			
5.0-6.4 Same as above, wet				2			
6.4-8.4 Light brown Sand very fine to fine grain, wet				3			
10.0-10.8 Dark gray - black Sand medium to coarse grain, very wet				4			
10.8-11.5 Dark gray - green Clay mottled, moist				5			
11.5-12.5 Same as above				6			
12.5-12.7 Brown clayey Sand iron stains, fine grain, moist				7			
				8			
				9			
				10			
				11			
				12			
				13			



# Illinois Environmental Protection Agency

BORING NO. <u>B-85</u>		WELL NO. <u>G1005 G185</u>		GROUNDLEVEL ELEV.		PAGE <u>2</u> OF <u>2</u>		
COUNTY <u>Madison</u>		SITE NO. <u>L11904007</u>		START DATE	FINISH DATE	ANNUOUS FILL MATERIAL		
BORING LOCATION <u>Granite City / Taracorp</u>				START TIME	FINISH TIME	PACKING		
DRILLING EQUIPMENT		SIZE		TYPE		SCREEN		
COMPLETION DEPTH		BEDROCK DEPTH		TOP OF CASING		PERSONNEL		
WELL CASING				TYPE AND QUANTITY				
SCREEN INTERVAL				TYPE AND QUANTITY				
ELEV	DESCRIPTION	DEPTH	Sample No	Sample Type	Sample Recovery %	Penetration (lb/ft)	H Value (ft)	REMARKS
<u>406.94</u>		<u>13</u>						
	<u>13.0-14.5 Brown Sand very fine to fine grain, thinly bedded, iron stains along bedding, moist</u>	<u>14</u>	<u>S<sub>7</sub></u>	<u>SS</u>	<u>1.1</u>		<u>10/14</u>	
<u>404.94</u>	<u>14.5-16.0 Same as above</u>	<u>15</u>	<u>S<sub>8</sub></u>	<u>SS</u>	<u>0.9</u>		<u>6/5</u>	
	<u>16.0-17.5 Same as above, wet at bottom</u>	<u>16</u>						← H <sub>2</sub> O
		<u>17</u>	<u>S<sub>9</sub></u>	<u>SS</u>			<u>4/3</u>	
	<u>17.5-19.0 Same as above</u>	<u>18</u>	<u>S<sub>10</sub></u>	<u>SS</u>			<u>11/14</u>	
	<u>19.0-20.5 Same as above, although no iron stains</u>	<u>19</u>						
<u>399.94</u>		<u>20</u>	<u>S<sub>11</sub></u>	<u>SS</u>			<u>12/12</u>	Pulled auger up to 20.0ft. and installed well.
	<u>20.5-22.0 Brown Sand fine grain, some black streaks at bottom along bedding, wet</u>	<u>21</u>	<u>S<sub>12</sub></u>	<u>SS</u>			<u>7/11</u>	
<u>397.94</u>	<u>Boring complete</u>	<u>22</u>						



# Illinois Environmental Protection Agency

BORING NO. B-8D		WELL NO. G1000 G18D		GROUND LEVEL ELEV. 420.00		PAGE 1 OF 2	
COUNTY Madison		SITE NO. L11904007		START DATE 7/28/83		FINISH DATE 7/28/83	
SITE Granite City/Taracorp				ABOVE PACKING silica sand and bentonite		ANNULUS FILL MATERIAL	
BORING LOCATION West of pile near propane tanks				START TIME 7:00A.		FINISH TIME 11:30A.	
DRILLING EQUIPMENT CME 55 3 1/4 inch I.D. hollow stem auger				PACKING concrete with Ca bentonite		SCREEN in situ sand	
COMPLETION DEPTH 35 ft.		BEDROCK DEPTH -		TOP OF CASING 421.88 PVC		PERSONNEL	
WELL CASING 2 inch I.D. flush joint threaded schedule 40 PVC				SAMPLES			
SCREEN INTERVAL 27.26 - 32.26 ft. PVC #10 slot 2 inch I.D. flush joint threaded schedule 40				PERSONNEL			
ELEV. 420.0				REMARKS			
DESCRIPTION				DEPTH			
20.0-25.0 Brown <u>Sand</u> fine grain, wet				0			
				20			
25.0-30.0 Same as above, gray at bottom				21			
				22			
30.0-35.0 Gray <u>Sand</u> fine to medium grain, micaceous, brown staining from 34 to 35 ft., black streaks along beds through bottom 2 inches, wet				23			
				24			
				25			
				26			
				27			
				28			
				29			
				30			
				31			
				32			
				33			
				34			



# Illinois Environmental Protection Agency

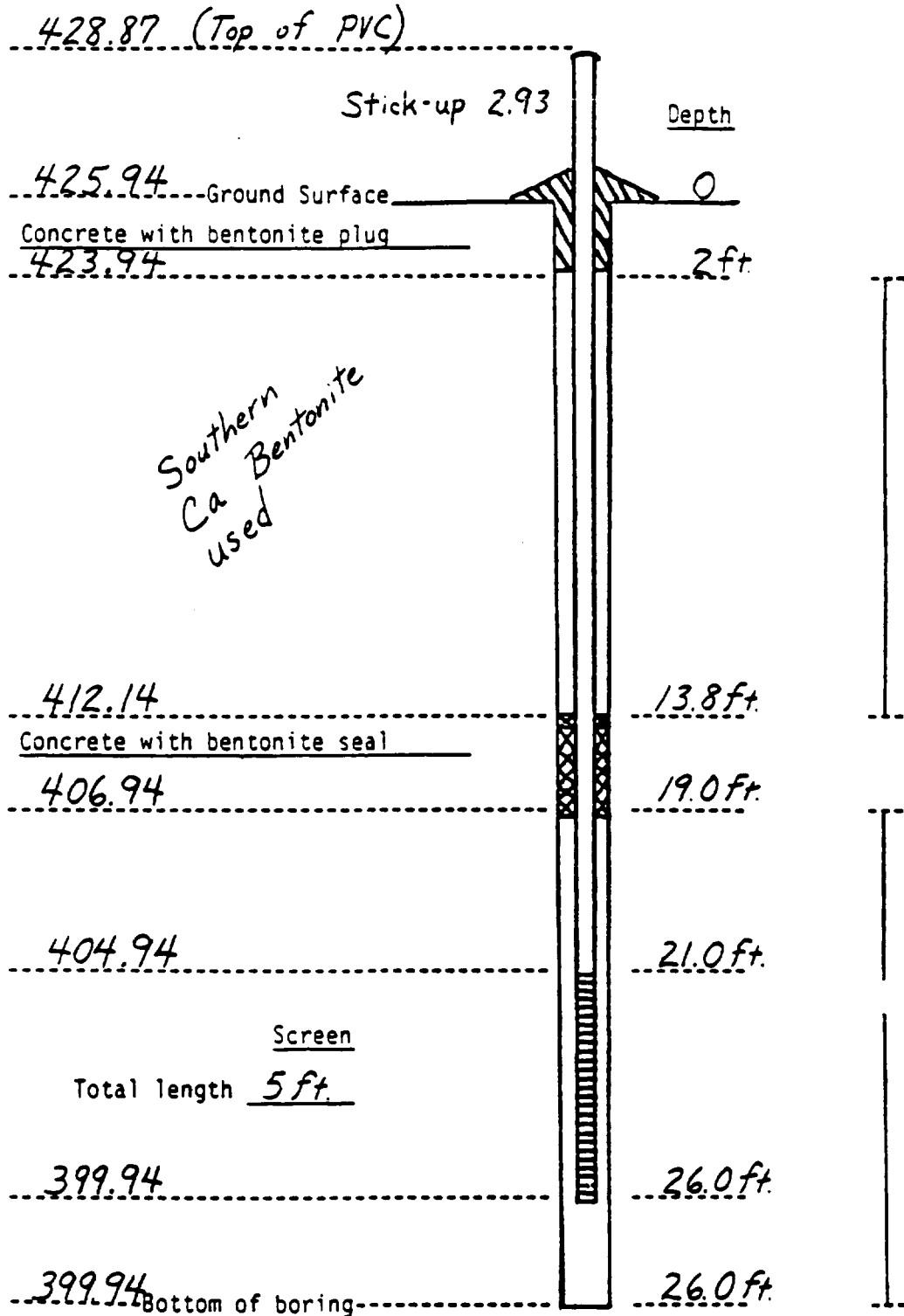
BORING NO. <b>B-8D</b>		WELL NO. <b>G1088 G18D</b>		GROUNDLEVEL ELEV. <b>420.0</b>		PAGE <b>2</b> OF <b>2</b>			
COUNTY <b>Madison</b>		SITE NO. <b>L11904007</b>		DATE		ANNUOUS FILL MATERIAL			
BORING LOCATION <b>Granite City / Taracorp</b>		START		FINISH		ABOVE PACKING			
DRILLING EQUIPMENT		SIZE		TYPE		PACKING			
COMPLETION DEPTH		BEDROCK DEPTH		TOP OF CASING		SCREEN			
WELL CASING		TYPE AND QUANTITY		SAMPLES				PERSONNEL	
SCREEN INTERVAL		TYPE AND QUANTITY		L I D I T				REMARKS	
ELEV	DESCRIPTION	DEPTH	Sample No	Sample Type	Sample Recovery Ft	Penetration (lb/ft)	N Value (blows)		
<b>387.0</b>		<b>33</b>							
	<b>30.0-35.0 Gray Sand fine to medium grain, micaceous, brown staining from 34 to 35ft.; black streaks along beds through bottom 2 inches, wet</b>	<b>34</b>	<b>S17</b>						
<b>385.0</b>	<b>Boring complete</b>	<b>35</b>							

# MONITOR WELL CONSTRUCTION

Well No. G 155  
~~G 1055~~

Prepared by: S. Otto

Elev.

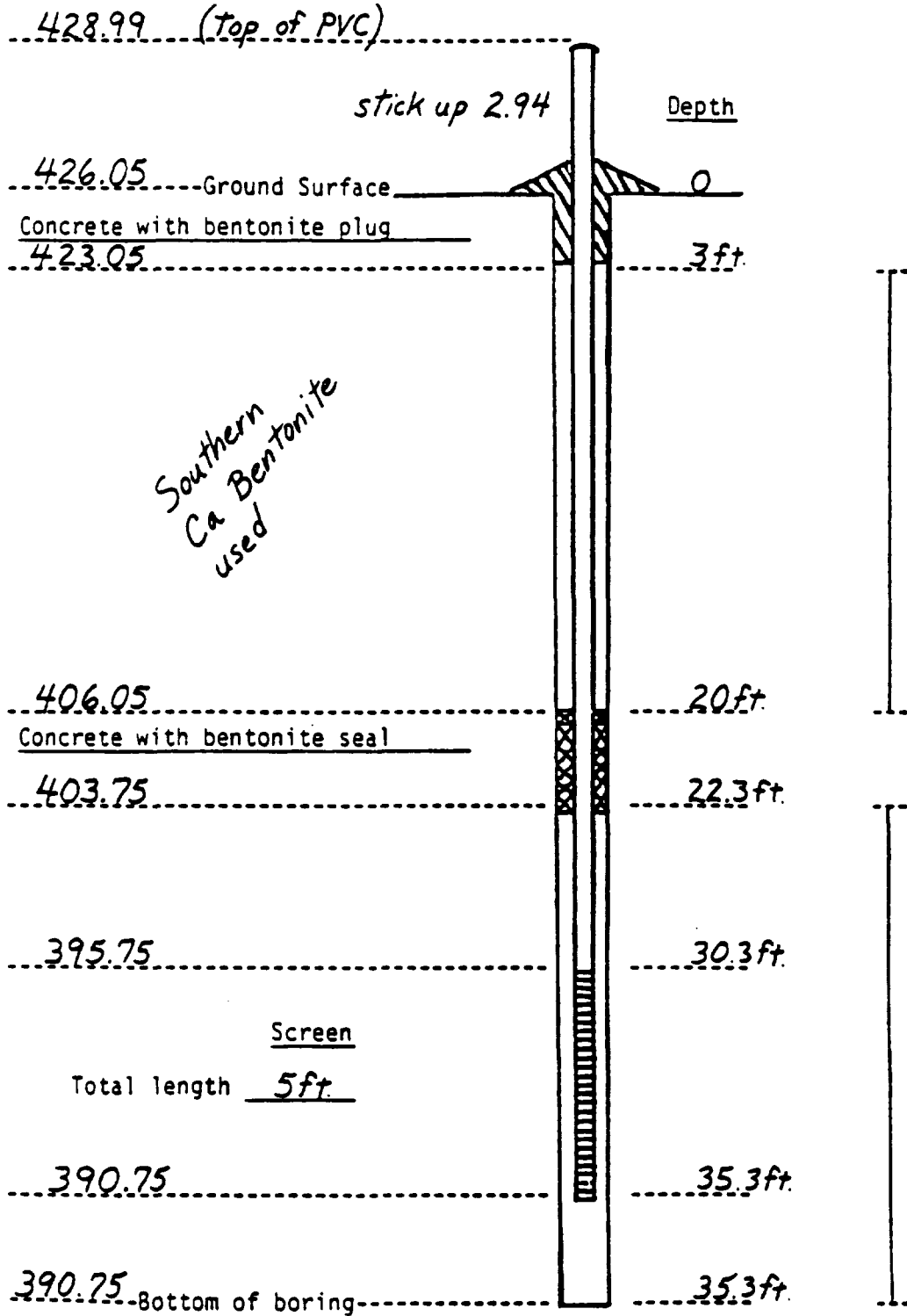


Pipe: Type and quantity 2 inch I.D. flush joint threaded schedule 40 PVC with #10 slot screen; total feet of casing including screen is 28.93 ft.; used teflon tape on threaded joints; a 5 ft. x 4 inch diameter steel protective cover was installed with padlock.

# MONITOR WELL CONSTRUCTION

G 15D  
Well No. ~~G 102D~~  
Prepared by: S. Otto

Elev.



Pipe: Type and quantity 2 inch I.D. flush joint threaded schedule 40 PVC with #10 slot screen; total feet of casing including screen is 38.19 ft.; used teflon tape on threaded joints; a 5 ft x 4 inch diameter steel protective cover was installed with padlock.

# MONITOR WELL CONSTRUCTION

G165

Well No. ~~G1065~~

Prepared by: S. Otto

Elev.

424.00 (top of PVC)

Stick up 2.88ft.

Depth

421.12 --- Ground Surface

Concrete with bentonite plug

417.12

4 ft

Southern  
Ca Bentonite  
used

Packed with silica  
sand and bentonite

412.62

Concrete with bentonite seal

8.5 ft

408.12

13 ft

405.33

15.79 ft

Screen

Total length 5 ft

Packed with silica  
sand 13 to 18.2 ft

400.33

20.79 ft

400.62

Bottom of boring

20.5 ft

Pipe: Type and quantity 2 inch I.D. flush joint threaded schedule 40 PVC with #10 (0.01 inch) slot screen; total feet of casing including screen is 23.67 ft.; used teflon tape on threaded joints; a 5 ft. x 4 inch diameter steel protective cover was installed with padlock.

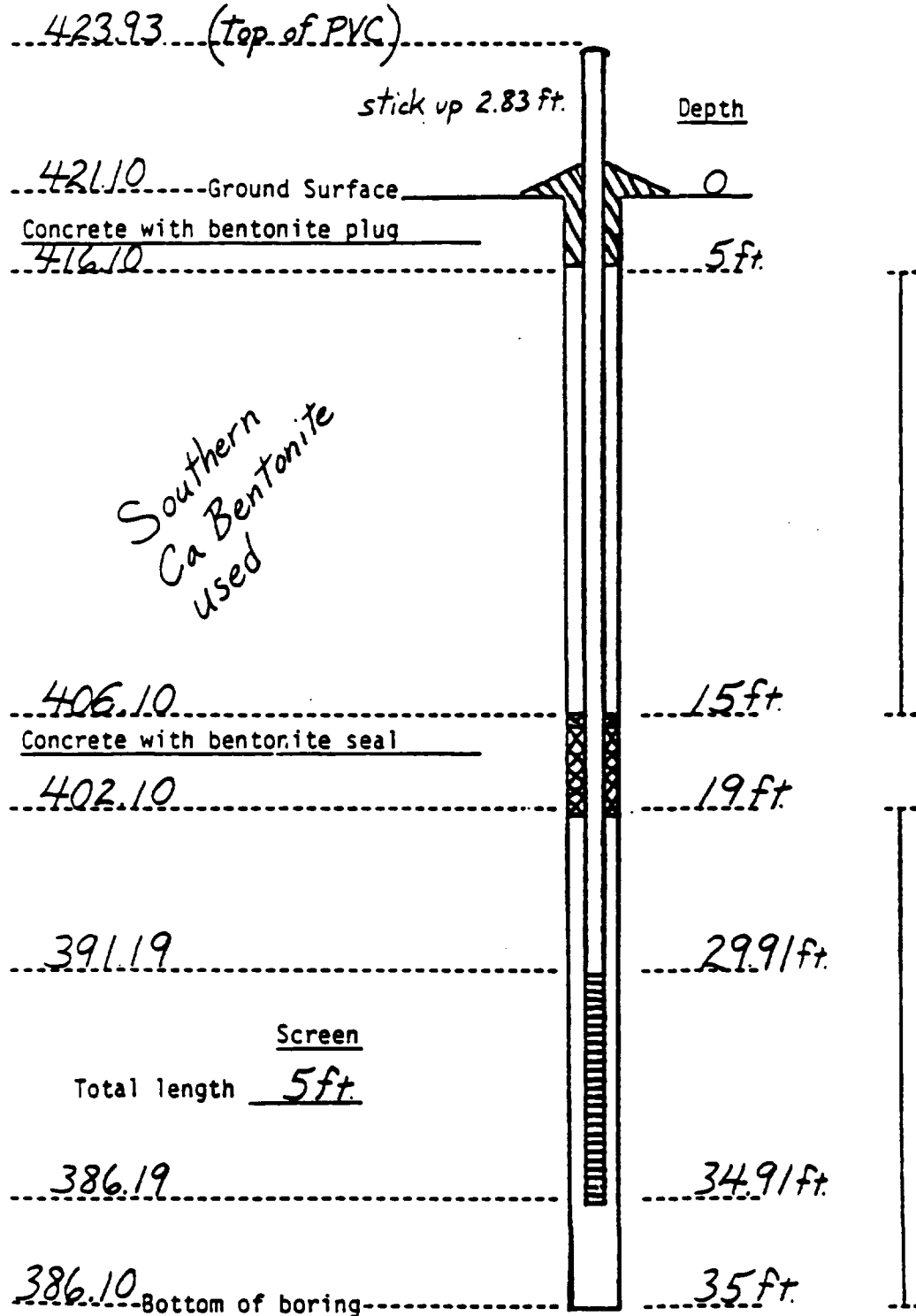
# MONITOR WELL CONSTRUCTION

G16D

Well No. ~~G106D~~

Prepared by: S. Otto

Elev.



Pipe: Type and quantity 2 inch I.D. flush joint threaded schedule 40 PVC with  
#10 (0.01 inch) slot screen; total feet of casing including screen 37.74 ft.;  
used teflon tape on threaded joints; a 5 ft. x 4 inch diameter steel  
protective cover was installed with pad lock.

# MONITOR WELL CONSTRUCTION

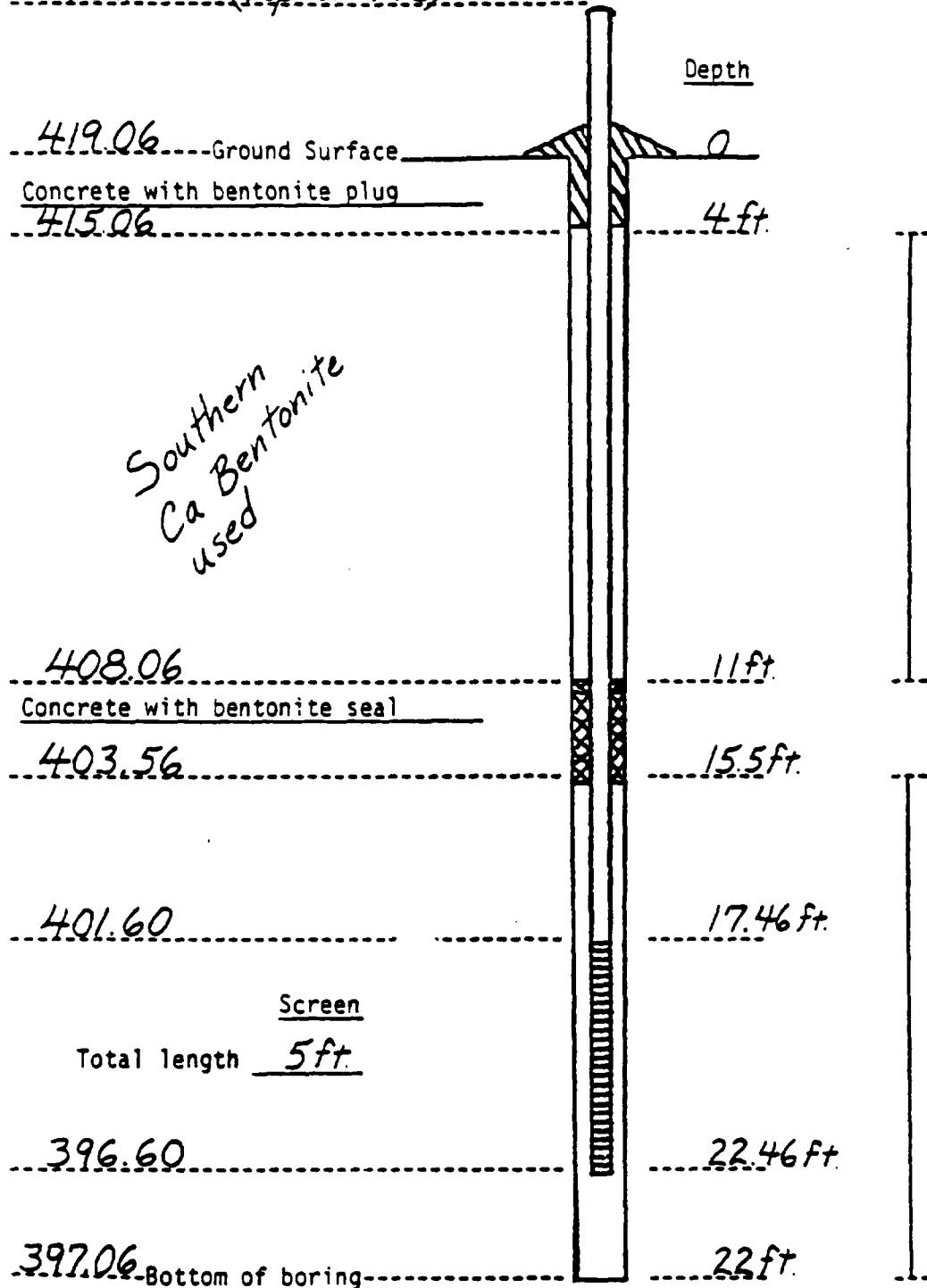
G175

Well No. ~~G1075~~

Prepared by: S. Otto

Elev.

421.07 (top of PVC)



Pipe: Type and quantity 2 inch I.D. flush joint threaded schedule 40 PVC with #10 (0.01 inch) slot screen; total feet of casing including screen is 24.47 ft.; used Teflon tape on threaded joints; a 5 ft x 4 inch diameter steel protective cover was installed with pad lock.

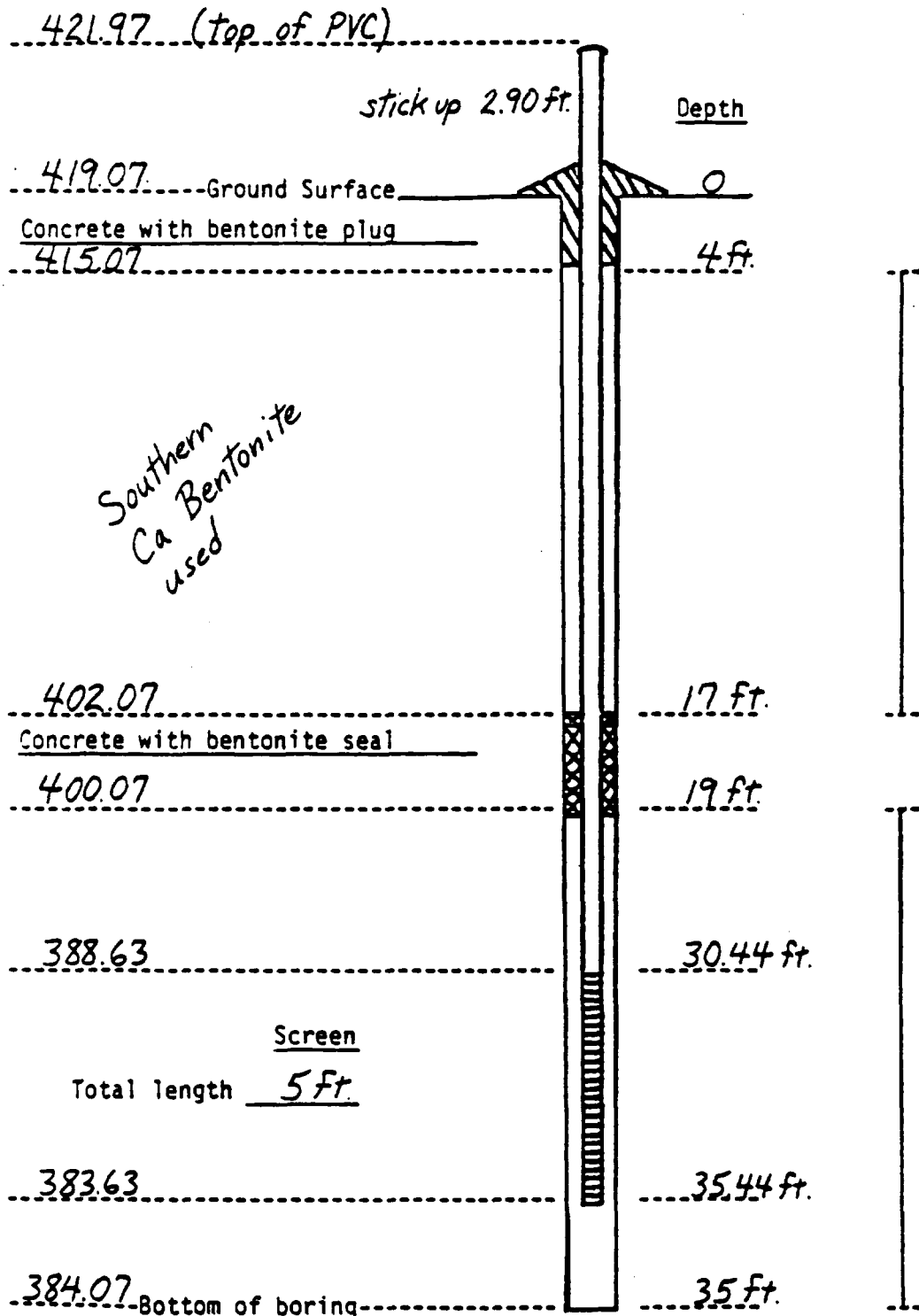
# MONITOR WELL CONSTRUCTION

G 17 D

Well No. ~~G 107 D~~

Prepared by: S. Otto

Elev.



Pipe: Type and quantity: 2 inch I.D. flush joint threaded schedule 40 PVC with #10 (0.01 inch) slot screen; total feet of casing including screen is 38.34 ft.; used Teflon Tape on threaded joints; a 5 ft x 4 inch diameter steel protective cover was installed with padlock.

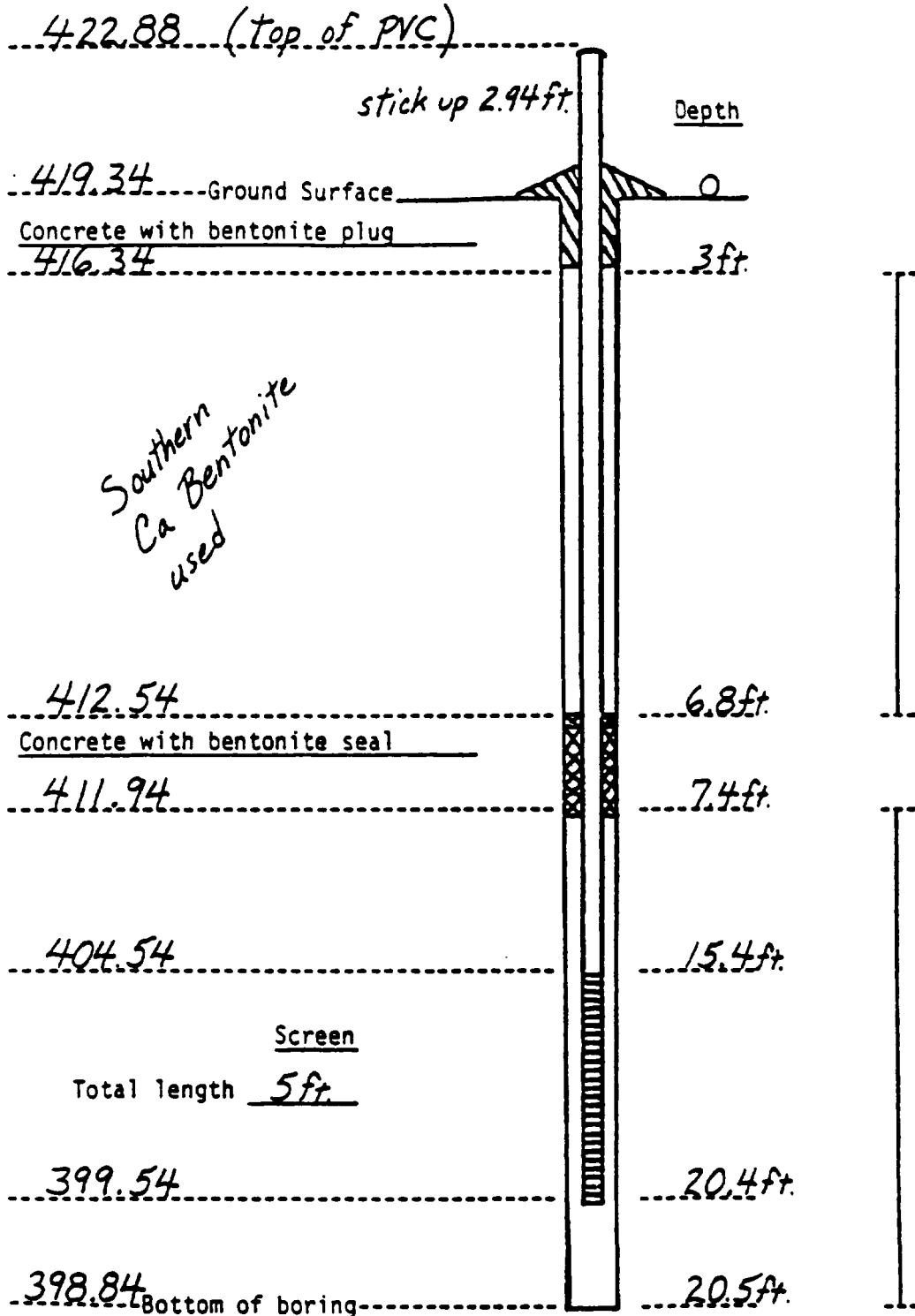
# MONITOR WELL CONSTRUCTION

G185

Well No. ~~F-108S~~

Prepared by: S. Otto

Elev.



Pipe: Type and quantity 2 inch I.D. flush joint threaded schedule 40 PVC with #10 (0.01 inch) screen; total feet of casing including screen 23.34 ft.; used Teflon tape on threaded joints; a 5 ft x 4 inch diameter steel protective cover was installed with padlock.

# MONITOR WELL CONSTRUCTION

G 18D

Well No. ~~G 108D~~

Prepared by: S. Otto

Elev.

421.88 (top of PVC)

stick up 1.88 ft.

Depth

420.00---Ground Surface

Concrete with bentonite plug

417.00

3 ft.

*Southern  
Ca Bentonite  
used*

Packed with silica  
sand and bentonite

414.00

Concrete with bentonite seal

412.00

6 ft.

8 ft.

392.74

27.26 ft.

Screen

Total length 5 ft.

Packed with

in situ sand

387.74

32.26 ft.

385.00

Bottom of boring

35 ft.

Pipe: Type and quantity 2 inch I.D. flush joint threaded schedule 40 PVC with #10 (0.01 inch) screen; total feet of casing including screen 34.14 ft; used teflon tape on threaded joints; a 5 ft x 4 inch diameter steel protective cover was installed with padlock.

# MONITORING WELL CONSTRUCTION DETAILS

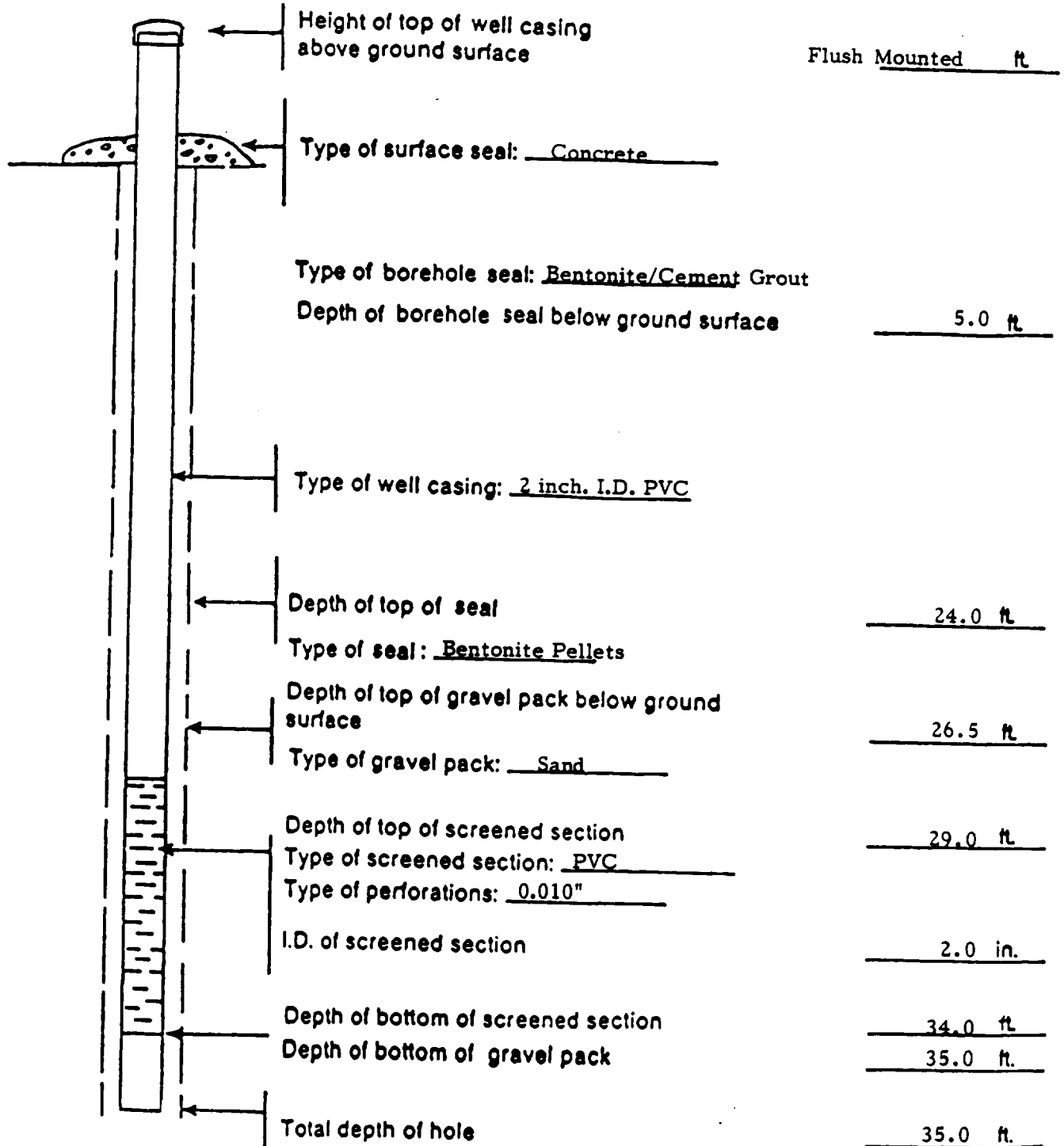
PROJECT N.L. Industries: Granite City Site

DATE COMPLETED July 29, 1987

WELL NO. MW-109

DRILLED BY \_\_\_\_\_

LOCATION Adjacent to RR, South of Site



# MONITORING WELL CONSTRUCTION DETAILS

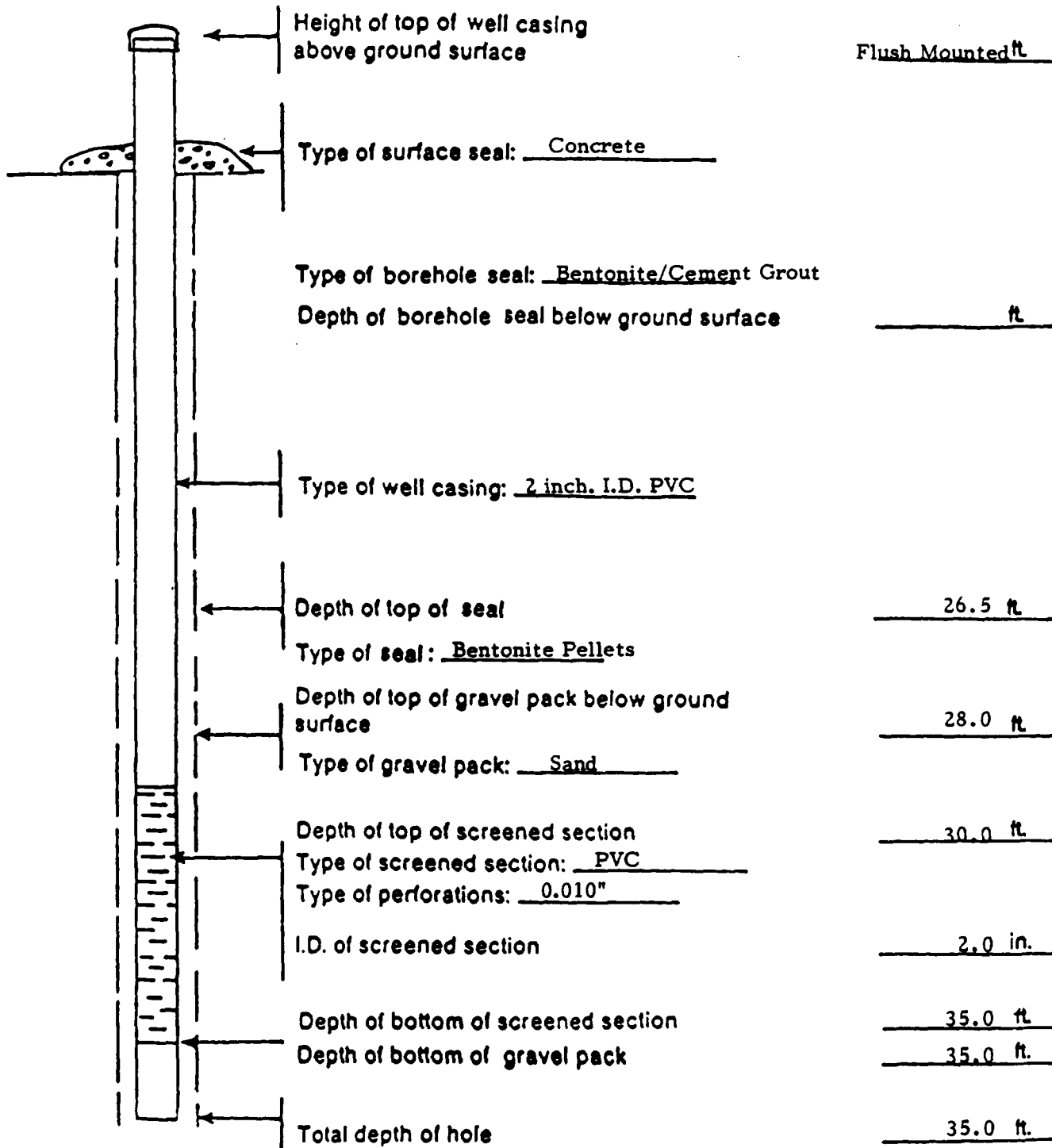
PROJECT N.L. Industries: Granite City Site

DATE COMPLETED July 30, 1987

WELL NO. MW-110

DRILLED BY \_\_\_\_\_

LOCATION Adjacent to Edison Street @ Monn's Residence



<b>O'BRIEN &amp; GERE ENGINEERS, INC.</b>		<b>TEST BORING LOG</b>		<b>REPORT OF BORING NO. MW-109 SHEET 1 OF 2</b>			
<b>PROJECT LOCATION:</b> Granite City, Ill. <b>CLIENT:</b> NL Industries		<b>SAMPLER</b> TYPE: ASTM Method 1585-0 HAMMER: FALL:		<b>GROUND WATER</b> DEPTH      DATE      ELEV. DEPTH      DATE      ELEV. <b>FILE NO.:</b> 2344.012.005			
<b>BORING CO.:</b> <b>FOREMAN:</b> <b>QBS GEOLOGIST:</b> R. J. Foresti		<b>BORING LOCATION:</b> Adjacent to R & R, south of site <b>GROUND ELEVATION:</b> <b>DATES:</b> STARTED: / /      ENDED: / /					

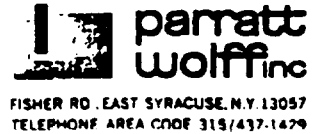
DEPTH	SAMPLE				SAMPLE DESCRIPTION	STRATUM CHANGE DEPTH	EQUIPMENT INSTALLED	FIELD TESTING			R
	No.	DEPTH	SLUGS /5'	PENETRY/RECOVERY				SPL. 0/00	SP. COND.	RHU	
0		0.5-2	4-5-4	2/2	Gravel fill at surface over dark brown silt, sand, gravel and brick fragments, moist, loose.						
2		2-4	3-4-4-3	2/2	Black silt, sand, some gravel, moist, loose.						
4		4-5	3-5-7-11	2/2	Black silt, sand, some gravel, moist, loose.						
5		5-8	3-5-5-7	0.5/2	Olive green to grey silt and clay, moist, firm to soft.						
8		8-10	2-3-5-5	2/2	Olive brown silt and very fine sand, trace clay, moist, loose.						
10		10-12	4-5-10-15	2/2	Medium brown very fine to medium sand, horizontal bedding, moist, loose.						
12		12-14	5-10-9-11	2/2	Medium brown very fine to medium sand, horizontal bedding, moist, loose.						
14		14-15	5-9-11-12	2/2	Medium brown very fine to medium sand, horizontal bedding, moist, loose.						
15		15-18	8-11-10-12	2/2	Medium to light brown fine, to coarse sand, moist, loose.						
18		18-20	3-5-7-17	2/2	Medium to light brown fine, to coarse sand, sand, moist, loose, saturated.						
20		20-22	15-12-13-17		Medium to light brown fine, to coarse sand, moist, loose, saturated.						
22		22-24	3-9-13-23		Medium to light brown fine, to coarse sand, moist, loose, saturated.						
24		24-25	9-13-12-13		Olive brown fine to coarse sand, saturated, loose.						
25		25-28	7-17-25-35		Olive brown fine to coarse sand, saturated, loose.						
28		28-30	5-12-20-19		Olive brown fine to coarse sand, saturated, loose.						
30		30-32	2-5-9-15		Olive brown fine to coarse sand, saturated, loose, with trace gravel.						



[illegible]

[illegible]

**EXHIBIT C**



December 1, 1987

O'Brien and Gere Engineers  
1304 Buckley Road  
Syracuse, New York 13221

Attention: Mr. Douglas M. Crawford  
Project Engineer

Re: L-87004  
Laboratory Testing  
NL Granite CIM  
File #2844.012.517

Gentlemen:

Enclosed are results of six Flexible Wall Permeability tests including visual soil descriptions performed at your request on Shelby tube soil samples delivered to our laboratory for the above project.

Thank you for this opportunity to work with you.

Very truly yours,

PARRATT - WOLFF, INC.

Donald P. Blasland, CET  
Laboratory Manager  
DPB/sar  
encs:

# FALLING HEAD FLEXIBLE WALL PERMEABILITY

Sample No.	Sample Location	Field in-place density results			Shelby tube Specimen Height cm.	Shelby tube Specimen Diameter cm.	Permeability results				
		Dry Unit Weight lbs/cu.ft.	Moisture Content	Percent Compaction			Confining Pressure psi	Test Pressure psi	Tail Pressure psi	Gradient	Coefficient of Permeability k (cm/sec)
			% of dry Weight								
			Optimum	Maximum							
	Depth of Total Sample (test sample)		(1)								
B-1	8.5' - 10.5' (bottom of tube)		23.0		10.60	7.11	71.0	68.0	64.0	26.5	6.69 x 10 <sup>-7</sup>
B-2	9.0' - 11.0' (bottom of tube)		30.5		10.46	7.11	71.0	68.0	64.0	26.9	6.13 x 10 <sup>-8</sup>
B-3	4.5' - 6.5' (top of tube)		36.7		9.85	7.11	71.0	68.0	64.0	28.6	1.32 x 10 <sup>-7</sup>
B-4	4.5' - 6.5' (top of tube)		32.5		10.03	7.11	71.0	68.0	64.0	27.3	3.98 x 10 <sup>-8</sup>
B-7	6.5' - 8.5' (middle of tube)		40.6		10.08	7.11	71.0	68.0	64.0	27.9	1.97 x 10 <sup>-8</sup>
B-8	4.0' - 6.0' (top of tube)		28.2		10.35	7.11	71.0	68.0	64.0	27.2	5.02 x 10 <sup>-8</sup>

(1) Natural moisture content (oven dry)

### VISUAL SOIL DESCRIPTION

- B-1 Gray-brown moist silt place fine sand place clay mottled appearance, possible organic material
- B-2 Gray moist silt little to some clay mottled appearance, possible organic material
- B-3 Gray moist silt little to some clay mottled appearance, debris (including brick fragments) possible organic material
- B-4 Gray moist silt little to some clay mottled appearance, possible organic material
- B-7 Graymoist silt little to some clay mottled appearance, possible organic material
- B-8 Gray moist silt little to some clay mottle appearance, fine debris, possible organic material

EXHIBIT D

RECEIVED  
OCT 11 1983  
ENVIRONMENTAL  
CONTROL

Study of Lead Pollution

in

Granite City, Madison and Venice, Illinois

April 1983

Illinois Environmental Protection Agency  
2200 Churchill Road  
Springfield, Illinois 62706

N. L. INDUSTRIES, INC.  
CONFIDENTIAL INFORMATION

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## 1) INTRODUCTION

During the last quarter of 1981, the Illinois Environmental Protection Agency's (IEPA's) air pollution monitor at 15th and Madison Streets in Granite City registered an unusually high average of lead. The sudden increase in airborne lead was unexpected because, up until then, the lead levels had been declining at that location. A preliminary investigation based on an analysis of meteorological data indicated that the lead came from the direction of the nearby lead smelter (Taracorp Industries) and a neighboring recycling operation (St. Louis Lead Recyclers). But a check with company officials and other area businesses did not reveal any obvious cause, such as an air pollution control equipment malfunction or a big jump in production. The average lead concentration at this monitoring site has since dropped, but at another monitoring site, it is still higher than the national health standard.

Up until the 1981-82 winter, the Agency thought that equipment and operating improvements at the smelter and the declining amount of lead in car exhausts would combine to bring airborne lead down to an acceptable level. But the jump in the 1981 fourth quarter average indicated that more may need to be done.

The Agency was concerned that the potential existed for another sudden rise in airborne lead and that unidentified sources of lead emissions might prevent the air quality of the area from improving. In mid-1982, the Agency began a more intensive investigation into the sources of lead in the vicinity of the monitor at 15th and Madison. To help pinpoint all the lead sources, another monitor was placed in the area. The Agency also began taking dust samples from open areas, streets and parking lots to get a more complete picture of where the lead was coming from and to assess the extent of contamination.

As part of the study the Agency also tried to determine if lead ingestion by people living in the study area is above recommended limits. Garden vegetable samples were collected, water testing records were reviewed, and soil samples were analyzed.

Another part of the study, conducted in cooperation with the Illinois Department of Public Health (IDPH), focused on the potential health effects of excessive lead levels in the environment.

This study report has been prepared by the IEPA. Participating in the data collection phase of this study with IEPA were the Illinois Department of Public Health, the United States Environmental Protection Agency, the United States Food and Drug Administration and the City of Granite City.

The hazard assessment portion of the study and the health-related recommendations contained in this report were developed by the IEPA in close cooperation with the Environmental Toxicology and the Lead Poisoning Control programs of the Illinois Department of Public Health. Their input and critical review of Section X of this report were particularly helpful.

## II) SUMMARY, FINDINGS AND RECOMMENDATIONS

Although significant contamination of the environment exists in the vicinity of the secondary lead smelter, the preliminary assessment of the IEPA and the IDPH is that a major near-term risk to public health is unlikely to exist provided that ambient air quality levels do not exceed the National Ambient Air Quality Standard and that routine personal health and hygiene measures are followed. However, the high levels of lead found in the soil on and near the smelter site are cause for continued concern. Because uncertainty remains regarding the long-term health implications of these high soil-lead concentrations, prudence dictates that dust control measures be implemented immediately. Further ground water and blood testing planned for the area will indicate what additional pollution control measures are necessary to reduce health hazards.

### A) Blood Samples

1. The Illinois Department of Public Health (IDPH) took blood samples from 97 individuals in 43 households within two miles of the lead smelter in Granite City during November and December 1982.
2. The amount of lead and FEP (a lead-related enzyme) found in the blood samples falls in the range considered to be acceptable by health practitioners. No cases of lead blood poisoning were found, nor were there any excessively high blood lead levels. Blood-lead tests are an indicator for lead exposure during the previous 90 days only. FEP tests, however, are indicative of longer exposures. The IDPH considers a blood-lead level of 30 micrograms per deciliter (ug/dl) or greater, in combination with an FEP level of 50 ug/dl or greater, to be dangerously high. For children six years old or less, the blood-lead samples averaged 10 ug/dl and the FEP levels averaged 17 ug/dl.
3. Forty-six children age six and under were tested. This is not as many as the testing program set out to obtain and not enough to draw broad conclusions about the rest of the children living in the area. The results of the 46 children's blood tests, however, provided no evidence that there are lead-related health problems present in the area. If the blood-lead and FEP levels of children in the survey remained the same in the years to come, these children would not be expected to develop lead-related health problems.
4. Because uncertainty remains in the conclusions drawn from the blood sampling data, the IDPH will continue to offer free blood tests to residents at its Granite City office (4700 Nameoki Road, phone 618/931-4545).

8) Soil Samples

1. Lead levels in the soil in some residential areas are very high. Near the lead smelter two surface soil samples exceeded 5000 parts-per-million of lead.
2. Fifty surface soil samples gathered in Granite City, Madison and Venice indicate that soil out to a distance of one and a half miles from the lead smelter has higher lead content than the levels of 50-100 parts per million found in other communities.
3. Generally, soil within one-half mile of the smelter can be expected to contain 1000 parts per million of lead.
4. Many other studies that have found high lead concentrations in soil have also found high blood-lead levels in people living in the same area. That relationship was not found in this study.
5. The health and hygiene practices listed below are generally recommended for anyone living in an urbanized/industrialized area, but they are particularly important for people living within about one-half mile of the smelter because of the high lead levels in the soil.
  - A. Small children, generally six years old or less, should not be allowed to play in dirt. However, normal sport or play activities on dirt areas by children and adults do not need to be restricted.
  - B. No one in the area, especially children, should put dirt, dirty hands or dirty objects in their mouths.
  - C. Grass or other ground cover should be planted in residential yards where dirt is exposed.
  - D. Children should not eat outdoors if they are likely to get soil on food or on their hands while eating.
  - E. Everyone should wash their hands and faces thoroughly before eating.

C. Water Samples

1. Four groundwater monitoring wells were drilled by Taracorp at the Agency's request in November, 1982.
2. The initial groundwater samples have shown no significant lead pollution. However, not enough samples from different locations have been taken to draw conclusions. Sampling is continuing.

3. Granite City, Madison and Venice do not use groundwater as their source of drinking water. Drinking water test results fall well below the State's standard of 50 ug/l for lead.
4. A soil sample taken at the 14-15 foot level while drilling one well revealed an unusually high concentration of lead (2700 parts per million). Samples taken in the same boring at 5, 10, 20, 25 and 30 feet showed lead concentrations no higher than 50 ppm. Further sampling will have to be done to determine the cause of the high lead level at the 15-foot depth which was just above the water table.
5. Surface water runoff goes into the city's storm sewer system and subsequently to the waste water treatment plant. The effluent from the treatment plant meets lead water quality standards.

D. Garden Samples

1. In the fall of 1982 vegetables were taken from seven gardens in Granite City and analyzed in a United States Food and Drug Administration laboratory for lead. Soil samples were taken from each garden to see if a correlation existed between lead in the soil and lead in vegetables.
2. The garden vegetables analyzed included: peppers, tomatoes, banana peppers, cauliflower, eggplant, okra, carrots, tomatoes, cabbage, cucumbers, peas, squash, and beets.
3. Health experts estimate that on the average children 0-2 years old take in approximately 100 ug of lead each day in the food they eat. By the time children reach 8 1/2 years old they are taking in approximately 210 ug each day. The vegetables analyzed in this study showed higher lead levels where soil-lead concentrations were high. However, the levels were still low relative to the normal dietary intakes noted above.
4. Nevertheless, because of the high lead content of the soil, there are several recommendations that people with gardens within one-half mile of the smelter should follow:
  - A. All vegetables from home gardens should be washed thoroughly before being eaten.

- B. Garden soil should be tested periodically for phosphorous and pH levels. A neutral pH helps inhibit plant uptake of lead, as does an adequate amount of phosphorous.
- C. The Madison County Cooperative Extension Service Office (618/656-8400) can advise people on how to collect a proper sample and where to send it for analysis. It will cost approximately \$4 to have the phosphorous and pH tested. Additionally, the extension adviser will interpret the test results for gardeners and instruct them on how much lime or fertilizer needs to be added.

E) Air Samples

1. Lead monitoring began in Granite City and the rest of the State in 1978. Since then, the lead monitoring site at 15th and Madison Streets in Granite City has recorded 14 violations of the federal lead health standard (1.5 micrograms of lead per cubic meter of air as a quarterly arithmetic average).
2. The highest quarterly average at 15th and Madison was 7.3 ug/m<sup>3</sup>, measured in the last quarter of 1981. Prior to that, the highest average was 4.4. Since 1981 the highest quarterly average has been 1.9 ug/m<sup>3</sup>.
3. Wind speed and direction studies for those days when the highest ambient air concentrations of lead were measured show that the lead was coming from the direction of the Taracorp lead smelter.

F) Lead Source Evaluation

1. The Taracorp facility, which was purchased from N.L. Industries in 1979, is a secondary lead smelter located in Granite City. It takes lead from discarded batteries and other lead bearing wastes and reprocesses it into products such as sheet lead, solder, shot gun pellets, lead wool and lead ingots. The major process emission sources at Taracorp include a blast furnace, a rotary furnace, lead melting kettles and a battery breaker.
2. The smelter property contains a three-acre storage pile of broken batteries, blast furnace slag and other lead waste products.
3. Surface soil samples taken at the rear gate of the Taracorp smelter contained 140,000 to 300,000 parts per million (or 14 to 30 percent) lead.

4. On October 1, 1982, Taracorp Industries filed bankruptcy under Chapter 11 of the Federal bankruptcy laws and is seeking reorganization.
5. St. Louis Lead Recyclers, which began operation in 1980, is adjacent to Taracorp. Since 1982 it has been reclaiming lead from Taracorp's waste pile.
6. The IEPA's preliminary evaluation of these two operations indicates that lead emissions should be reduced. Consistent with this conclusion, the Agency has taken the following related actions:
  - A. Denied a recent permit renewal application submitted by Taracorp for its blast furnace and associated equipment. Taracorp has appealed this denial to the Illinois Pollution Control Board.
  - B. Coordinated with USEPA to obtain a formal engineering review of Taracorp and St. Louis Lead Recyclers and make recommendations regarding potential control measures. This review has been completed and a report is currently being prepared by USEPA.
  - C. Requested the Illinois Attorney General to review the number of environmental law violations found at these sites and to obtain legally binding agreements from the companies regarding the implementation of control measures.
7. Although additional analytical work is underway to further delineate the sources of lead emissions, the IEPA believes that certain dust control measures should be implemented immediately to minimize lead emissions. These measures include: on-site traffic control; the paving or treating of roadways, parking lots and other traffic areas; regular cleaning of paved areas; covering open dirt areas with vegetation; and, fencing to reduce wind erosion. These and other measures, as they are developed, will be incorporated in the Attorney General's enforcement activities.

### III) STATE IMPLEMENTATION PLAN FOR AIR POLLUTION CONTROL

The United States Environmental Protection Agency (USEPA) officially listed lead (Pb) as an air pollutant on March 31, 1976 and proposed regulations for a National Ambient Air Quality Standard (NAAQS) on December 14, 1977. After a lengthy comment period, final designation of a NAAQS of 1.5 micrograms of lead per cubic meter of air ( $\mu\text{g Pb}/\text{m}^3$ ) averaged over a calendar quarter was promulgated on October 5, 1978. On the same date, regulations for states to follow in developing a lead pollution control plan were also issued.

The IEPA completed the Illinois State Implementation Plan (SIP) for Lead (Vol. 9 of the Illinois SIP) in February 1981. Sixteen locations in the State were closely examined, but none were judged to present potential health problems, with the exception of the Granite City-Madison-Venice area.

IEPA formally submitted the Lead SIP to USEPA on July 21, 1981 and requested that two congressional townships (R10W, T3N; and R9W, T3N which encompass the civil townships of Venice, Nameoki and Granite City) in Madison County be designated nonattainment. In the March 22, 1982 Federal Register (Vol 47, No. 55) a final rulemaking was published by USEPA stating that the State had adequately demonstrated attainment and maintenance of the NAAQS for lead in all areas of the state except Granite City-Madison-Venice. The State is required to develop a control plan for the area that will ensure attainment and maintenance of the NAAQS. The control program measures implemented subsequent to completion of the Granite City-Madison-Venice lead study will form the basis for revision of the SIP.

The problem in the area is principally related to past and current emissions associated with a secondary lead smelter. This facility is presently owned by Taracorp Industries; however, prior to the fall of 1979, the facility was owned and operated by N.L. Industries. The analyses presented in this report and SIP Volume 9 indicate that current emissions from the facility still significantly contribute to air quality levels exceeding the national lead standard and that residual lead build-up in the soil surrounding the plant also contributes significantly to the ambient lead problem.

#### IV) HISTORY OF AFFECTED AREA

The area with significant lead environmental contamination includes southwestern Granite City, northern Madison and northern Venice.

Data on the highest ambient air lead concentrations and the most significant lead emissions has focused attention on a section of land containing two major facilities: Taracorp Industries, a secondary lead smelter; and St. Louis Lead Recyclers, a lead reclamation facility.

Taracorp purchased the existing secondary lead smelter from N.L. Industries (formerly National Lead Company) in August of 1979. N.L. Industries took over the facility from the United Lead Company in 1928. The United Lead Company had acquired the facility from the Hoyt Metal Company in 1903. Most of the smelter is believed to be of original construction.

St. Louis Lead Recyclers came into existence in 1980. The company's original purpose was to reclaim lead from batteries. However, it soon entered an agreement with Taracorp to begin reclaiming lead from Taracorp's waste pile. Reclamation operations on the waste pile began in 1982.

Many other industries are located in the general area but none of them appear to contribute substantially to the lead problem.

## V) PROCESS DESCRIPTION OF TARACORP AND ST. LOUIS LEAD RECYCLERS

### A) Taracorp

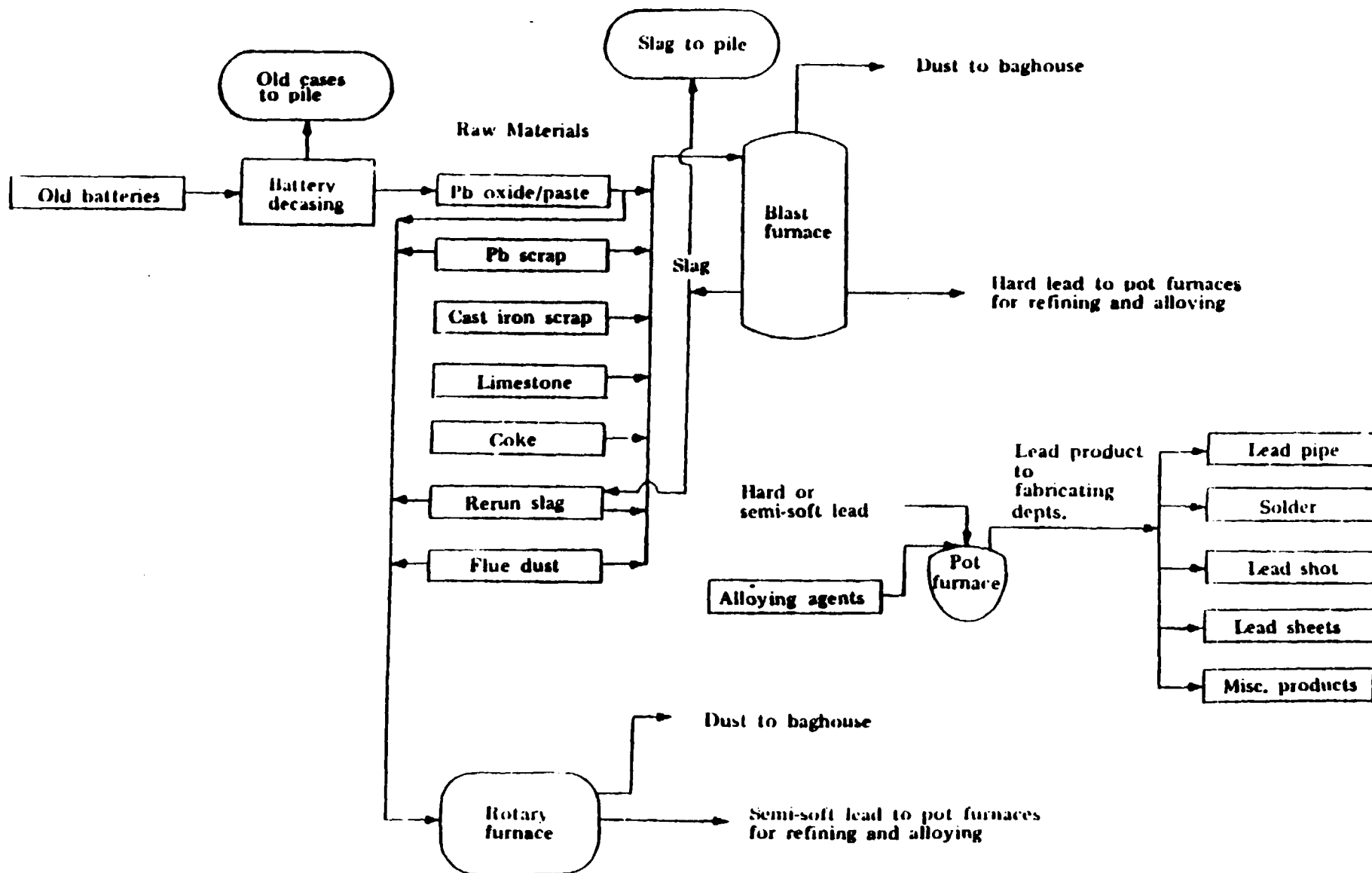
Taracorp is a secondary lead smelter which produces numerous lead products. These products include sheet lead, solder, shot gun lead pellets, lead wool, powdered lead and secondary lead ingots. The facility has a blast furnace (cupola), a rotary furnace, a number of lead melting kettles, a battery breaker operation, a natural gas fired boiler, and air pollution control equipment including several baghouses, cyclones, and an afterburner. A schematic of the Taracorp operation is provided in Figure V-1.

### B) St. Louis Lead Recyclers

St Louis Lead Recyclers reclaims various materials from the Taracorp waste pile. The process consists of the following steps:

- 1) Material from the waste pile is placed in a dump truck with a frontend loader. The truck is then weighed.
- 2) The material is then screened and hand sorted. Slag, matte, and trash are loaded back in the truck and reweighed. This weight is subtracted from the weight of material originally removed from the pile. The slag, matte, and trash have been returned to the pile in the past. However, the future disposition of this material is in question.
- 3) The remainder of the sorted material (battery cases, scrap, etc.) is transported to the recycling process.
- 4) The material for recycling is first crushed, shredded, and sprayed with a surfactant.
- 5) A wet separation process separates the lead oxide and elemental lead from the plastic and hard rubber (from battery cases).
- 6) An additional process separates the lead oxide from elemental lead. These materials are sold back to Taracorp, following aggregation in a quick-melt furnace.
- 7) The plastic and hard rubber are separated by floatation and washed. The plastic is sold to a plastic recycler. The hard rubber is presently being stockpiled while a market for it is being sought.
- 8) Water used in the process is clarified and recirculated.

Figure V - 1: Process Flow Diagram for Taracorp Secondary Lead Smelter



# VI) AIR POLLUTION ASSESSMENT

## A) Air Quality Monitoring

The IEPA's Division of Air Pollution Control has been monitoring ambient levels of lead on a statewide basis since mid-1978. Prior to 1978, lead air quality data were collected only within Cook County by local agencies. Table VI-1 lists the quarterly ambient lead averages (based on individual 24-hour samples taken every six days) for monitor locations (see Figure VI-1) in Granite City which have exceeded the Federal lead standard of 1.5 micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ) as a quarterly arithmetic average. The highest recorded quarterly average in Illinois was 7.3  $\mu\text{g}/\text{m}^3$ , monitored at the 15th and Madison Street monitoring site. This same site has recorded 14 violations of the lead standard during the period 1978 through 1982. This is the most violations recorded at any monitoring site in Illinois. The ambient lead data is presented graphically in Figure VI-2.

Table VI-1  
Ambient Lead Monitoring Data Summary  
(1978 - 1982)  
Quarterly Averages ( $\mu\text{g}/\text{m}^3$ )

<u>Yr/Qrt</u>	<u>15th &amp; Madison</u>	<u>20th &amp; Adams</u>	<u>Roosevelt &amp; Rock Rd.</u>	<u>1733 Cleveland</u>
1978 - 1	-	-	-	-
2	3.1	0.6	0.7	-
3	1.7	4.4	1.3	-
4	4.4	4.0	1.7	-
1979 - 1	2.6	1.0	1.3	-
2	3.2	0.9	1.2	-
3	2.0	1.1	1.3	-
4	3.0	2.6	1.2	-
1980 - 1	3.0	0.5	0.6	-
2	1.2	0.6	0.5	-
3	1.0	0.5	0.7	-
4	1.9	0.6	1.4	-
1981 - 1	2.1	0.5	0.5	-
2	1.0	1.6	0.9	-
3	1.8	0.5	1.1	-
4	7.3	0.5	0.9	-
1982 - 1	1.9	0.8	1.1	-
2	1.6	0.9	1.5	-
3	1.1	0.5	0.6	-
4	0.9	0.6	1.8	1.5

Figure VI - 1. LOCATION OF LEAD Air Quality Monitors

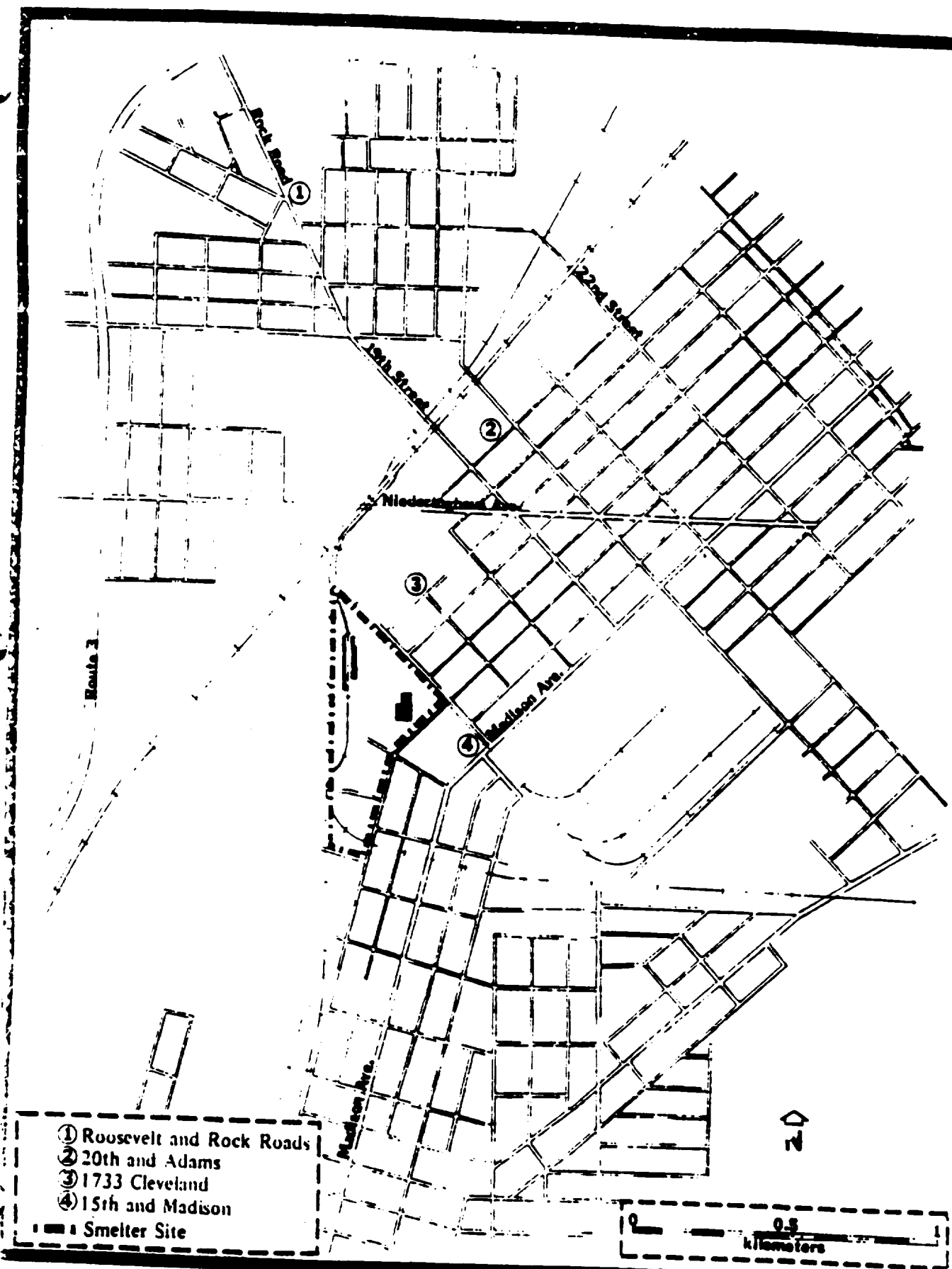
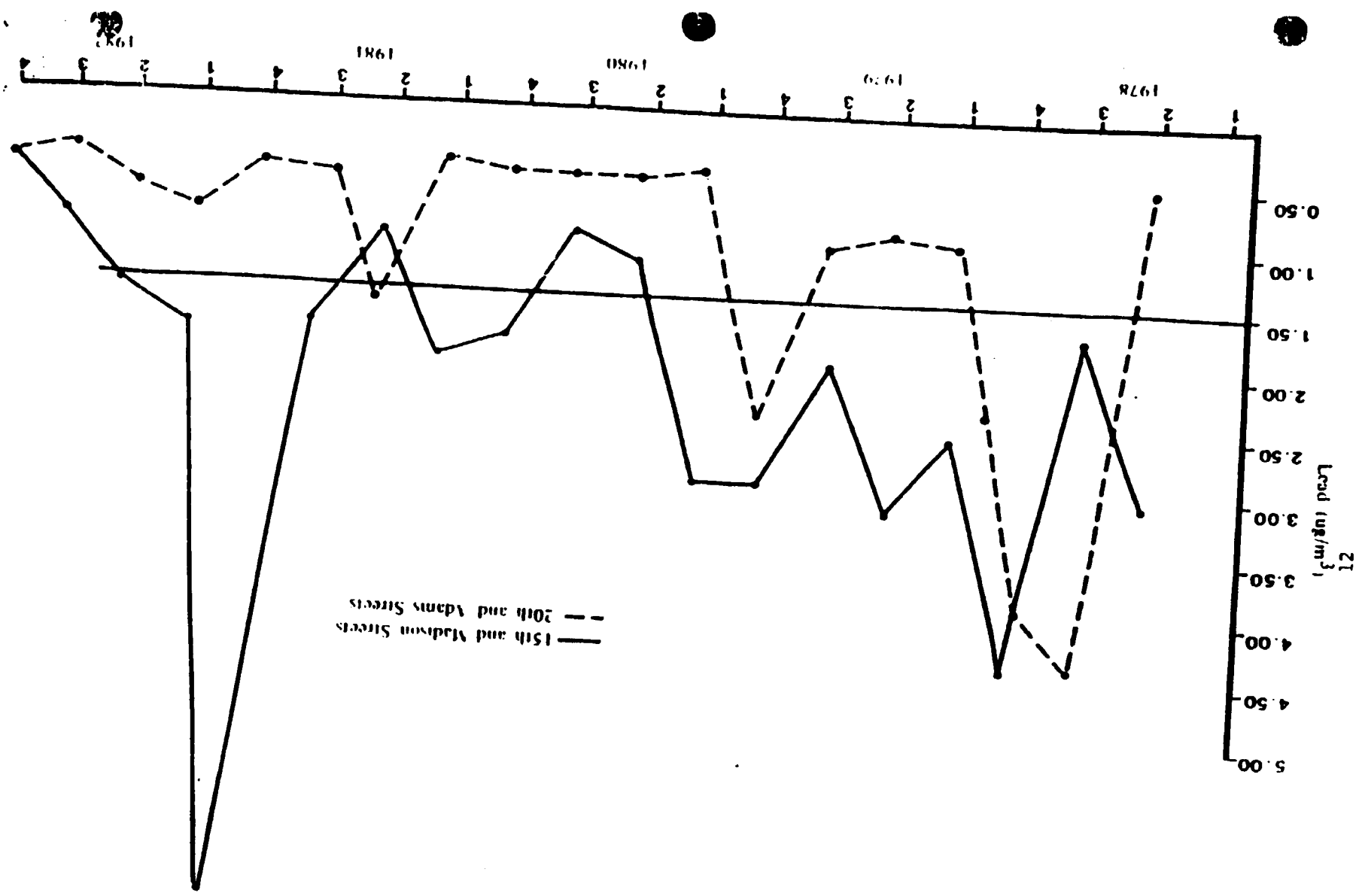


Figure VI - 2: Quarterly Ambient Air Lead Levels for Selected Granite City Monitors



#### B) Monitoring/Meteorological Analysis

To help pinpoint the emission sources contributing to high lead levels, composite wind frequency distributions were generated for each of three monitoring sites (15th and Madison, 20th and Adams, and Roosevelt and Rock Road) for days in 1981 and 1982 with lead concentrations greater than or equal to  $1.0 \text{ ug/m}^3$ .

The wind data used in the analysis was taken from the IEPA monitoring sites in East St. Louis and Edwardsville and the National Weather Service's station at Lambert Field in St. Louis.

Figure VI-3 is a graphical depiction of the composite wind frequency distributions (pollution roses) for 1981. Figure VI-4 depicts the wind directions at each site on high ambient lead concentration days in 1981. This cross-hatched area is indicative of the location of the most probable lead emission source contributing to the high lead concentrations.

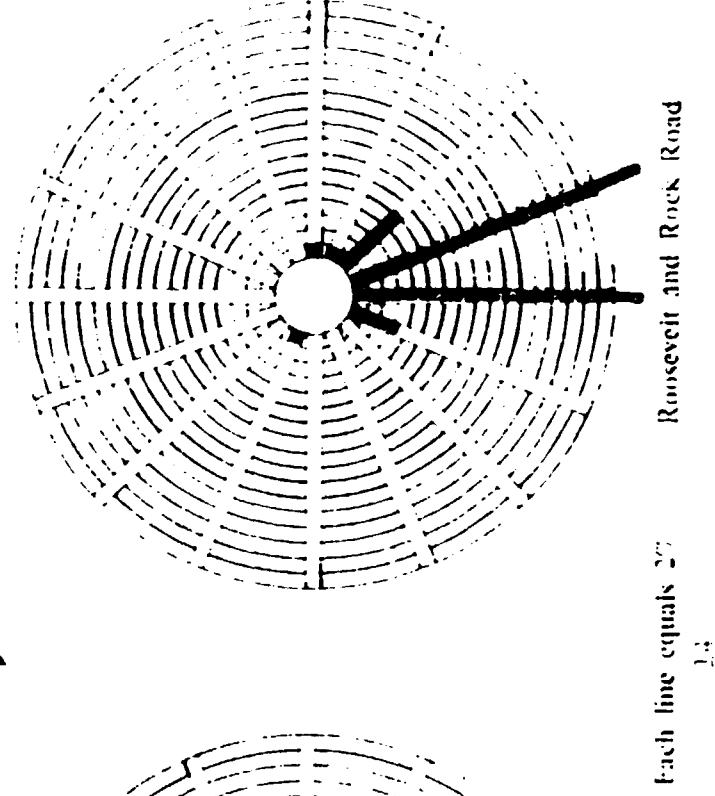
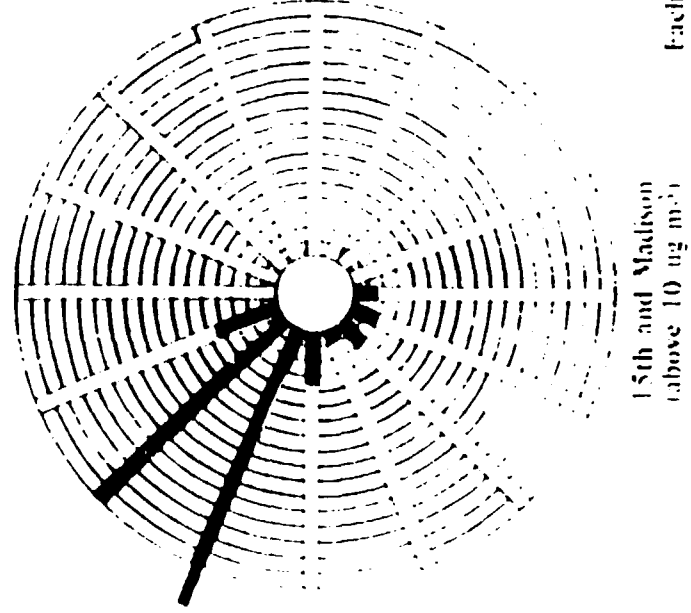
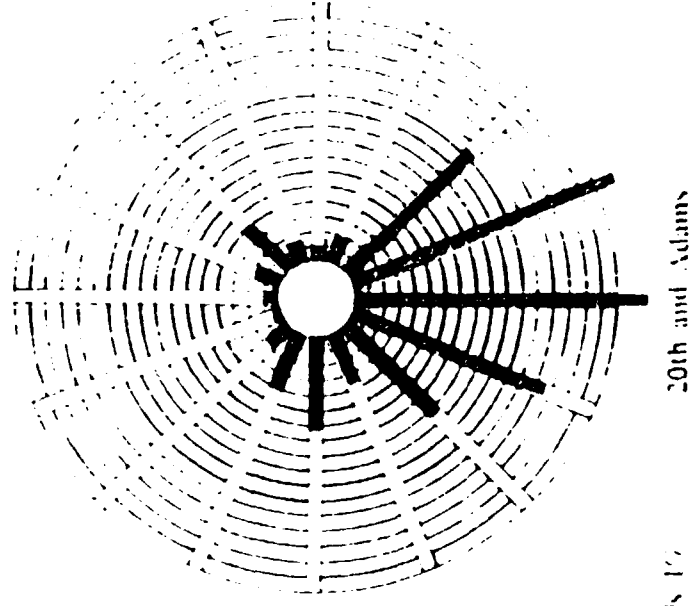
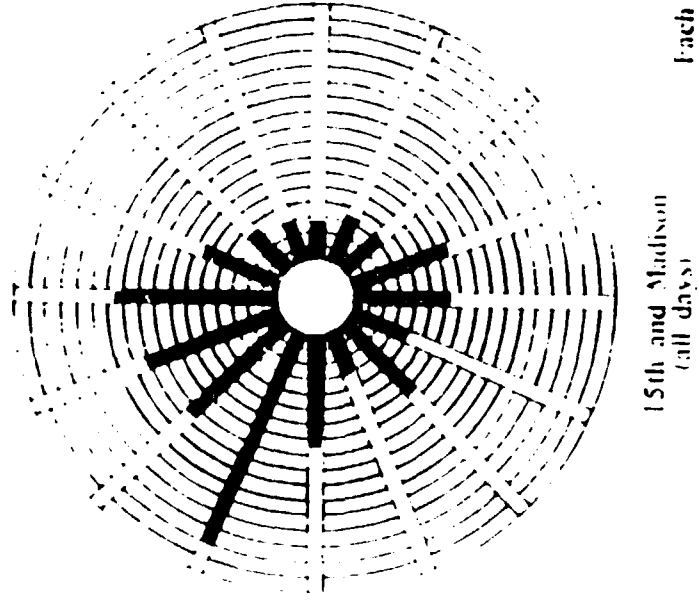
The same type of analysis was performed for 1982 wind data. Figure VI-5 depicts the pollution roses for the four monitors exhibiting high lead levels in 1982. Figure VI-6 depicts the range of the peak directions at each site on high ambient lead concentration days in 1982. Again, the cross-hatched area indicates the location of the most probable source contributing to the high lead concentrations. Taracorp Industries and St. Louis Lead Recyclers are located within the cross-hatched area. Less emphasis should be placed on the new monitor at 1733 Cleveland since it was only recently installed and, thus, operated for less than one-fourth of the entire year.

#### C) Deposition Patterns

Soil samples were taken throughout the area. Samples used to determine deposition patterns were taken from vegetated areas in which there was no evidence of recent disturbance (these samples were termed "Soil A"). In addition to determining the concentration of lead, several other metals were examined. Arsenic, antimony and tin were evaluated because they are generally present in significant quantities in lead smelter emissions.

Figure VI-7 presents the results for lead. Because of the relatively small sample size, these isopleths (i.e., lines connecting points of equal concentration) should be considered only rough approximations of equal soil-lead concentration areas.

Figure VI - 3: Wind Frequency Distribution on High Lead Days in Granite City During 1981



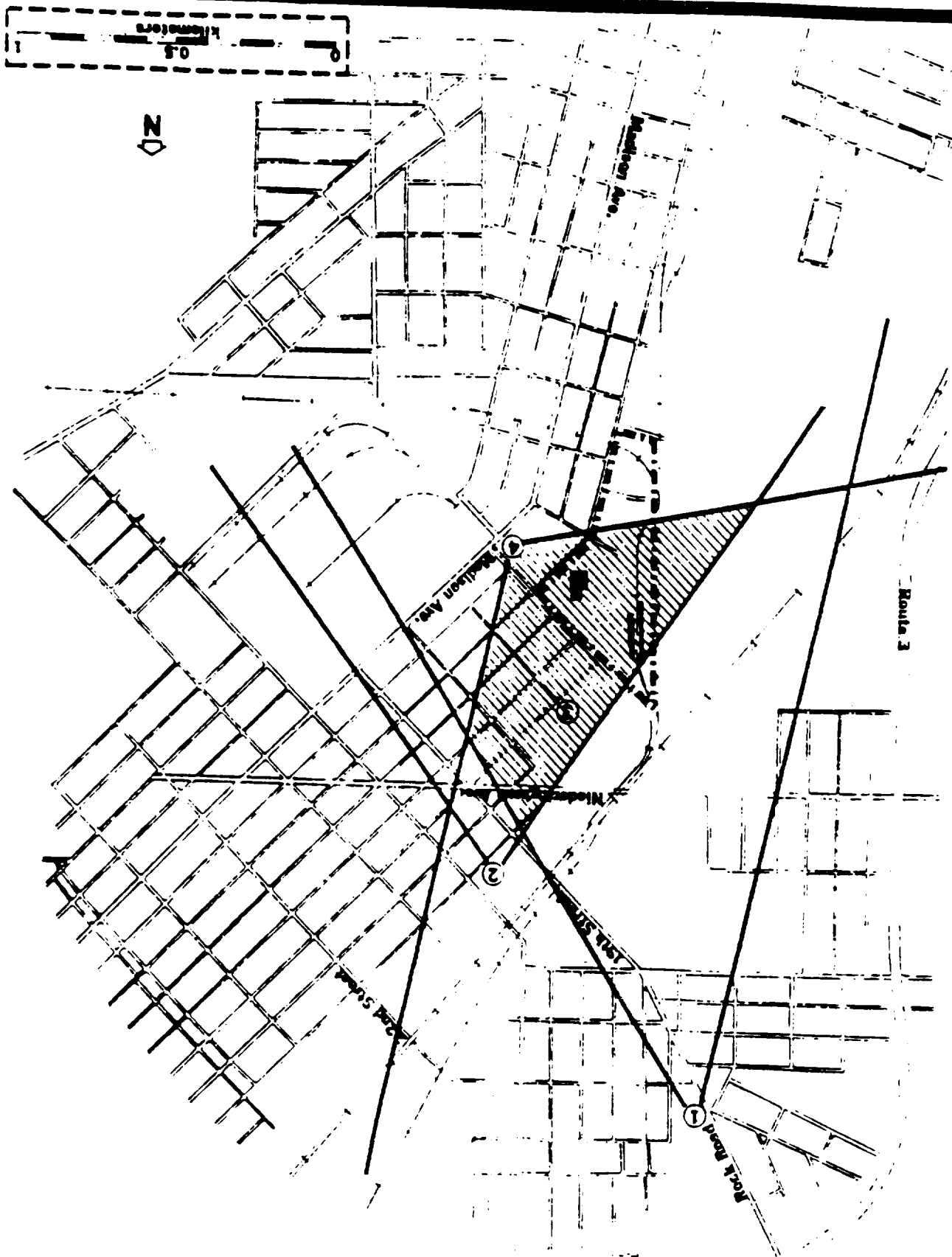
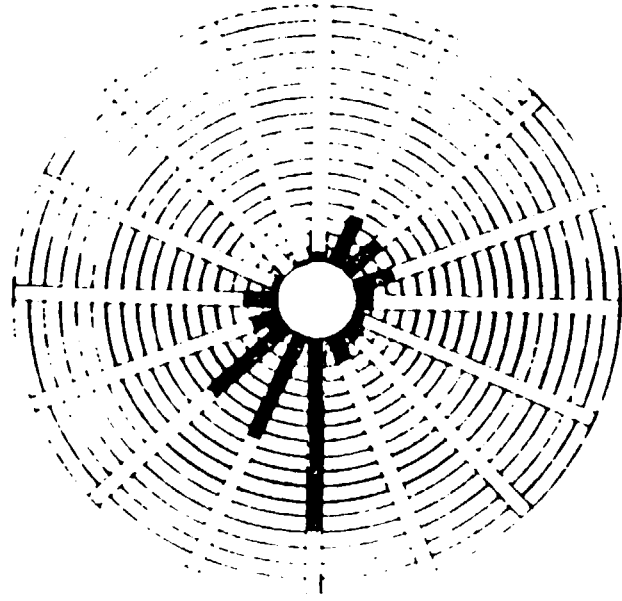


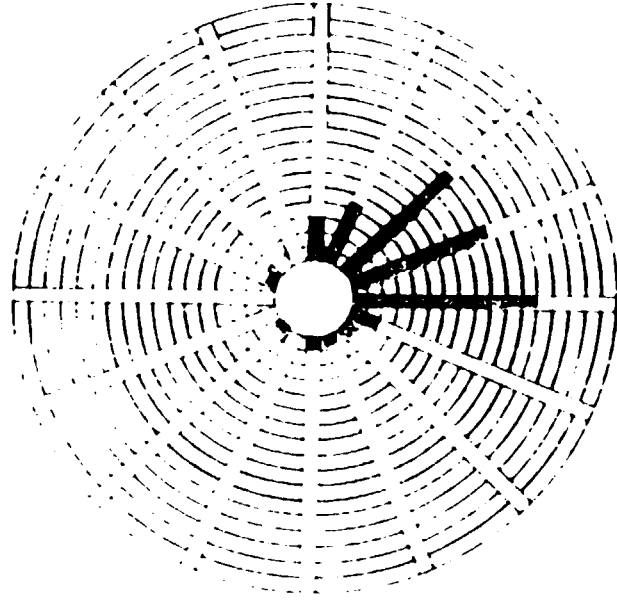
Figure VI - 4. Overlap of Lead Pollution roses for 1981

Figure A1 - 5: Wind Frequency Distribution on High Lead Days in Granite City During 1982

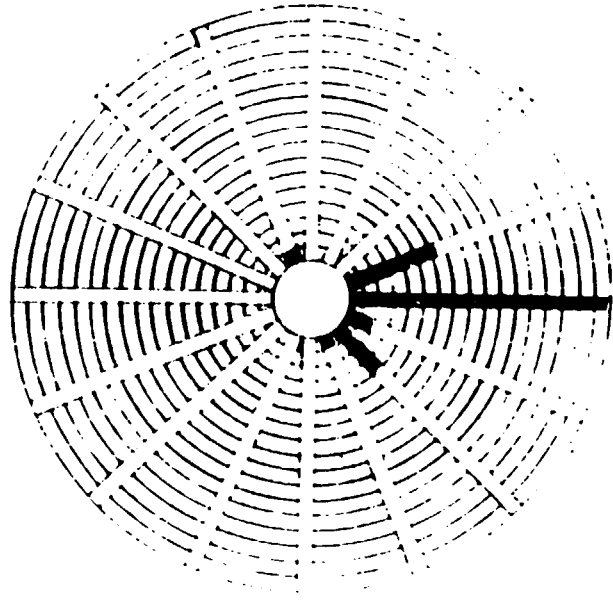
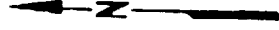


15th and Madison

Each line equals 2%

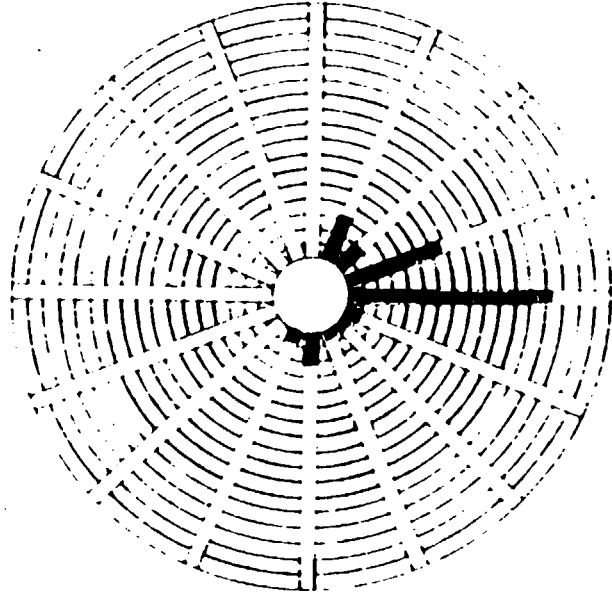


Roosevelt and Rock Road  
(does not include November)



20th and Adams

Each line equals 3%



1733 Cleveland

Figure 1. City Outline of San Francisco, 1902

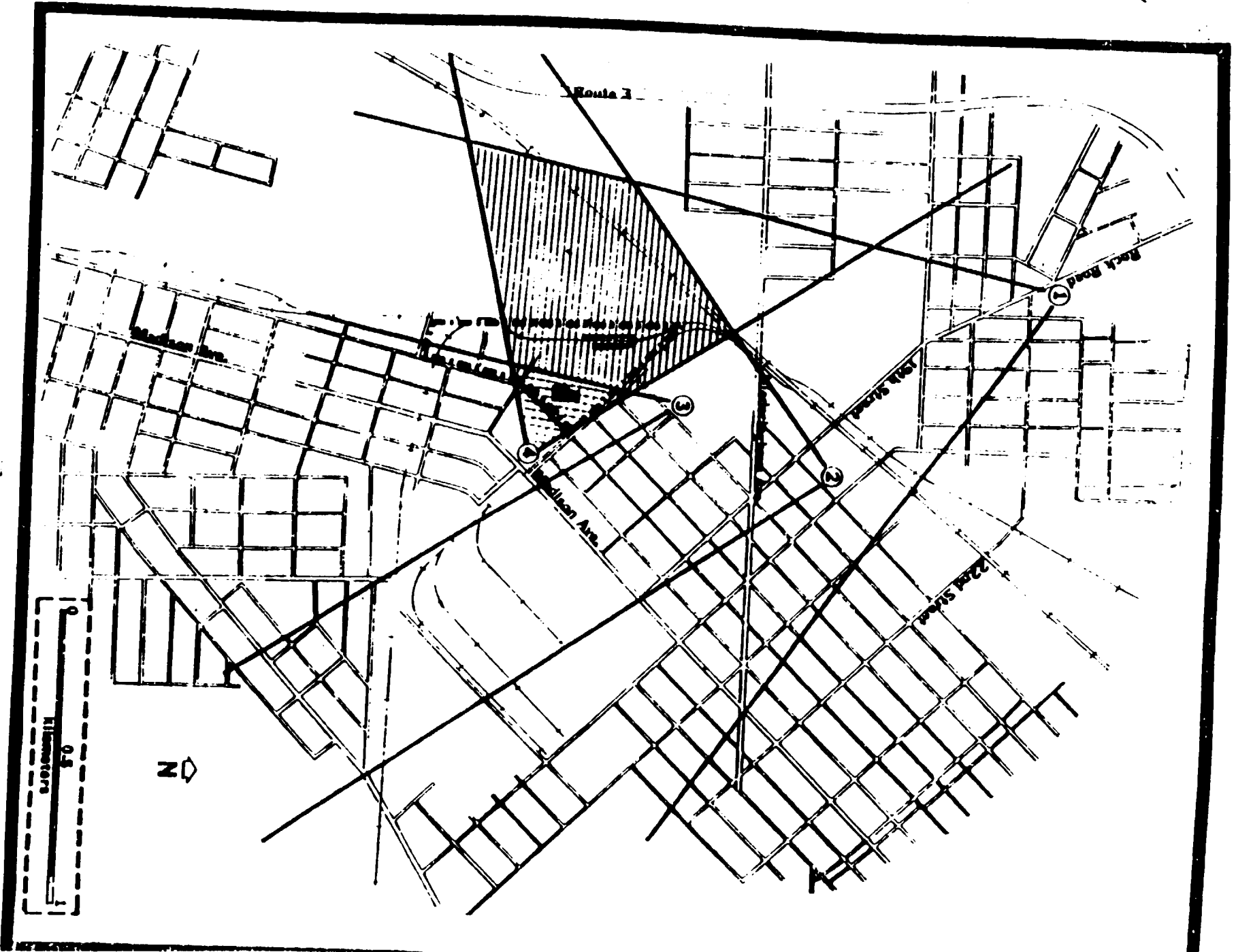
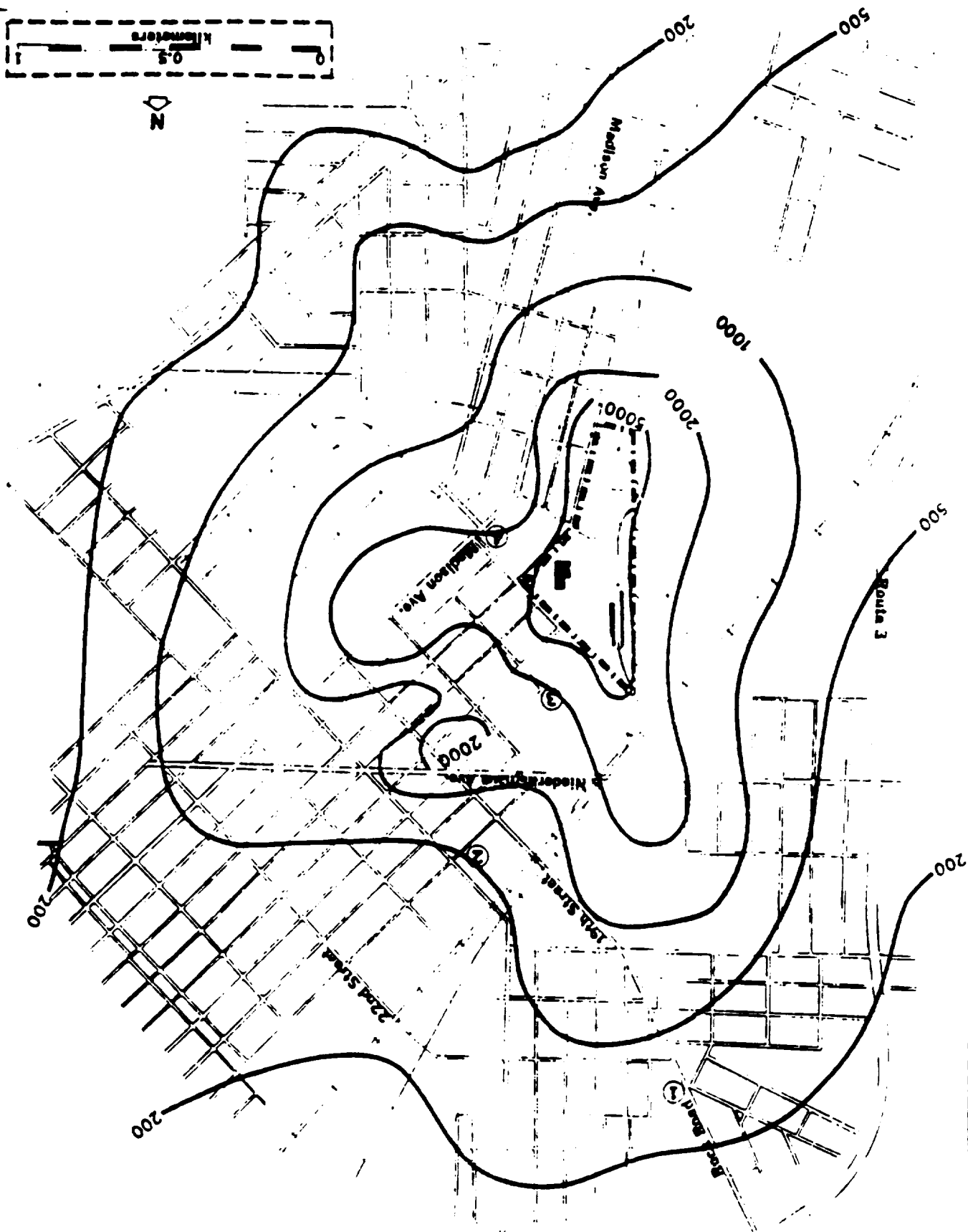


Figure VI - Lead Concentrations in Surface Soil (ppm)



0) Major Emission Sources

Emission sources at the smelter, the recycling operation and adjoining grounds can be placed in two general categories: process, and fugitive sources.

1) Process Sources

The Taracorp blast furnace (and associated activities) is the largest process source in the area. Materials handling activities prior to loading of the furnace skip hoist are discussed under the fugitive source section. Beginning with the loading of the skip hoist, however, significant process fugitive emissions are likely. The loading of the skip hoist and the subsequent charging of material into the furnace is poorly controlled. The charging of materials such as lead flue dust can cause significant emissions. Tapping operations are also poorly controlled and may contribute substantial emissions. Although under normal operations an attempt is made to control exhaust gases from the blast furnace, the overall system configuration does not represent good engineering practice. Under malfunction or charge bridging conditions, excess emissions are likely.

The rotary furnace is a second major potential emission source when in use. Poor hooding capture efficiency may allow significant emissions to escape into the "Mixed Metals A" building, where they are subsequently emitted to the ambient air.

Numerous kettles and operations throughout the facility are uncontrolled. Although not major sources taken individually, such sources may contribute substantial emissions when taken together.

Other process sources at both Taracorp and St. Louis Lead Recyclers should not contribute significant emissions under normal operations, but may be major sources under malfunction situations.

2) Fugitive Sources

Fugitive emissions are a significant cause of air quality problems in the area.

Handling of lead bearing material, particularly flue dust and battery plates, may result in significant emissions. This is especially true for the materials handling activities associated with blast furnace operations.

As discussed in Section IX, Land Pollution Problems, the soil on-site is heavily contaminated with lead. Resuspended dust from vehicular traffic as well as wind blown dust from the ground and waste storage piles can produce large quantities of lead particulate.

Additionally, the working of the waste pile can generate significant fugitive emissions.

#### E) Receptor Modeling

A detailed dispersion modeling analysis of lead air quality in the Granite City-Madison-Venice area was completed by the IEPA in February 1981. This analysis, which is discussed in detail in Volume 9 of the Illinois State Implementation Plan (SIP), indicated that both plant-related and non plant-related (i.e., fugitive emission) sources contribute to the elevated lead air quality levels in the area. The study also explained that a portion of the elevated lead levels in the area could not be accounted for with the emissions inventory that was used.

To provide for a more definitive analysis, a refined lead emissions inventory has been developed based on a more complete understanding of sources in the area. The factors contributing to this better understanding are as follows:

- 1) improved guidance concerning source emission factors;
- 2) more detailed knowledge of plant operations;
- 3) results of soil-lead sample analyses; and
- 4) updated estimates of lead emissions associated with motor vehicle activity.

To take advantage of the latest analytical tools available for verifying the significant sources of lead in the area, the IEPA has begun using receptor modeling techniques.

Until recently, dispersion models have been relied upon to apportion source impacts based upon assumptions regarding emission factors, plume behavior and meteorology. These models are sometimes not sufficient to accurately assess short-term source impacts or account for the sources contributing the total mass at a particular monitor. This is largely the result of the difficulties involved in developing realistic 24-hour inventories. In many instances receptor models, which incorporate data collected at a receptor (monitor) in order to deduce source impacts, have proven to be better for the short-term investigation of particulate sources. Receptor models can best be used in a complimentary fashion to improve accuracy and add confidence to the dispersion modeling analysis.

In this study the Chemical Element Balance (CEB) model, which matches source chemical "fingerprints" to those measured at the monitor in order to back-calculate the contributions from specific sources and source classes, is being used. This method requires that the suspected sources of lead and the monitor filters be analyzed for several chemical species by percent weight. X-ray fluorescence is recommended as a cost-effective and efficient method of analysing the samples for the spectrum of elements needed to explain the bulk of the particulate mass collected at the monitors. In the CEB model certain "fitting" elements are chosen based on experience and trial and error. These are used to construct a set of predictive equations, which are weighted to account for the uncertainties in the measurements of the various chemical species. This set of equations is then iteratively solved using statistical techniques. When an adequate fit is achieved, the mass contributed to the monitor by each source is computed for that day. By analyzing multiple days and considering meteorological data, an adjustment can often be made to the various emission factors used in dispersion modeling. Dispersion modeling analysis is still the best approach to determining the spatial extent of pollutant concentrations.

The CEB model has been programmed and is working. Some minor program refinements and test runs are necessary before the actual data is analyzed. Source samples have been collected and monitor filters have been selected for the chemical analysis. Arrangements have been made through USEPA Region V to have the chemical analysis performed. The company which is performing the analysis has extensive experience in both x-ray fluorescence and receptor modeling. Analysis of the filters by the contractor will be completed by the end of May 1983.

#### F) Air Quality Modeling

To further refine the dispersion modeling done previously, more extensive analyses will be conducted using the Industrial Source Complex Model (ISC). This model is listed as the USEPA Guideline Model designed to evaluate air quality in the vicinity of industrial complexes.

Point source, area source, and mobile source emissions are input to the model consistent with IEPA understanding of their operating rates during 1981. As it becomes available, the information resulting from the receptor modeling analysis will be used to supplement and refine the inventory which has been prepared. The results predicted by the model for each calendar quarter will be compared with lead air monitoring data collected during the same period. Based on these results, a correction factor will be developed for subsequent use with the model in this area.

Surface meteorological data collected by the National Weather Service (NWS) at St. Louis Lambert Field is being used. Upper air data from the nearest NWS site (Salem, Illinois) is being used as a basis for mixing height information.

The portion of the Granite City-Madison-Venice area being evaluated consists of a circular area, one mile in diameter, centered on the Taracorp facility. The density of theoretical receptors is greatest near the center of the area.

The revised air quality modeling analyses will be completed in the summer of 1983. These analyses will assist in determining the need for and adequacy of additional control measures beyond those already being considered.

## VII) GROUNDWATER POLLUTION ASSESSMENT

The Granite City-Madison-Venice area is located in the American Bottoms where the soil consists principally of sand to a depth of about 120 feet. Although lead is generally insoluble and does not readily migrate through soil, the sandy conditions of the area, as well as the potential acidic conditions caused by the presence of battery acid, make the likelihood of groundwater contamination much more significant.

The groundwater in the area is not used for public consumption. Several industries do use groundwater for process purposes, including 3.6 million gallons per day by Granite City Steel. The public water supply in the area is drawn from the Mississippi River and complies with the lead drinking water quality standards.

Four monitoring wells were installed by Taracorp in November 1982. IEPA's opportunity to provide input as to the location of these wells was minimal. The locations of the wells is indicated in Figure VII-1. The initial sample results for lead (as evaluated by IEPA) are presented below.

Table VII-1. Lead Concentrations in Groundwater  
(micrograms per liter - ug/l)

Well G101	Well G102	Well G103	Well G104
<u>&lt;5</u>	<u>&lt;5</u>	<u>&lt;5</u>	<u>60</u>

Since the drinking water standard for lead is 50 ug/l, the lead concentrations do not appear significantly elevated. However, the variation among wells with regard to lead concentration cannot be readily explained. In addition, these results are only preliminary, and no final conclusions should be drawn until additional samples are taken and at least one additional well is in place.

During the boring of Well G101, soil samples were obtained at every five-foot interval. These samples were then split with Taracorp and subsequently analyzed. The results of the Agency's analysis for lead is as follows:

Figure VII - 1 : Ground Water Sampling Well Locations

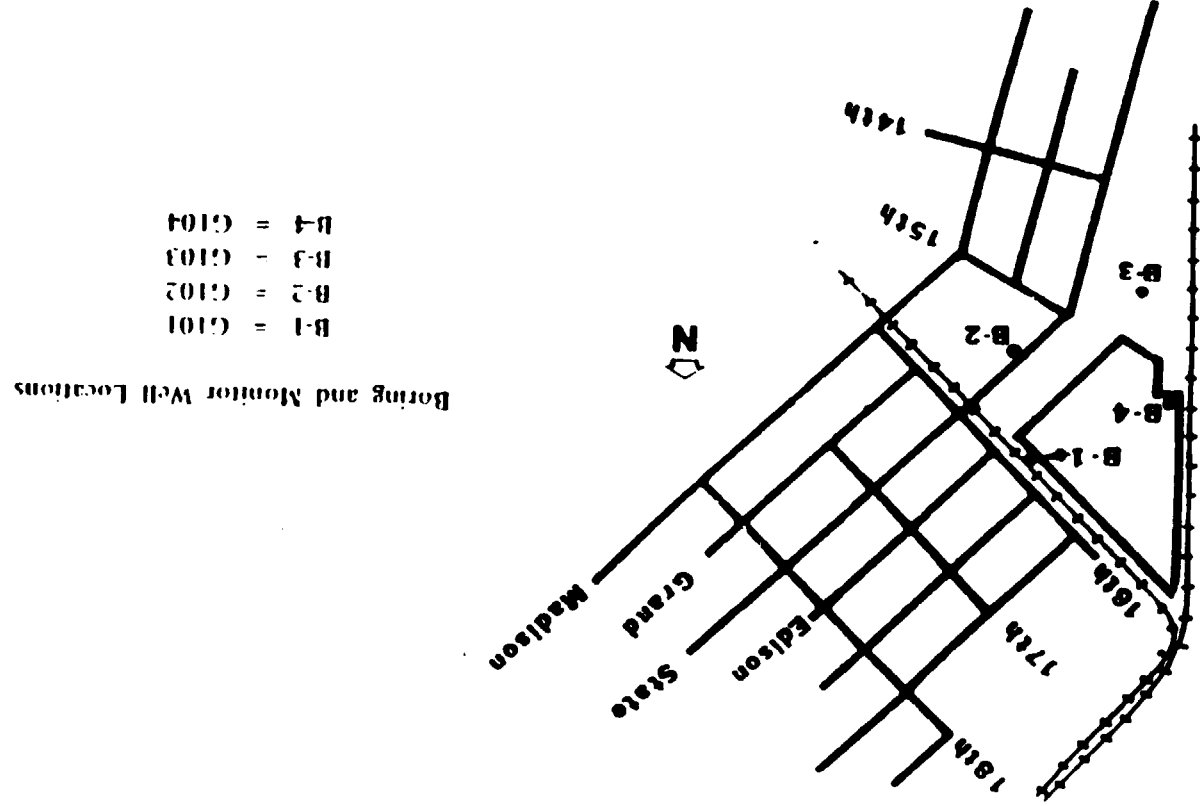


Table VII-2. Lead Concentrations at Various Depths in Soil  
Taken from Boring of Well G101 (parts per million)

	<u>Sample Depth</u>	<u>Lead Present in ppm</u>
(data in feet	4 - 5.5 feet	43
below ground	9 - 10.5 feet	51
surface)	14 - 15.5 feet	2700
	19 - 20.5 feet	43
	24 - 25.5 feet	14
	29 - 30.5 feet	13

From the preliminary data it appears that the lead may be migrating down through the soil 14-15 feet below ground surface and precipitating out. Further sampling will have to be done to determine the cause of the high lead level at this depth.

Listed below are the water elevations from the monitor wells. Notice the rise in elevation between the November and January sampling. The water elevations show a general movement of the groundwater to the southwest.

	November 16, 1982	January 26, 1983	February 28, 1983
G101	399.3	402.9	402.9
G102	399.2	-----	401.5
G103	398.2	402.1	401.9
G104	397.7	400.5	400.6

The water table during these three sampling periods was slightly below the level of the soil sample that had the 2700 ppm of lead. It appears from the water chemical analysis that at this time the lead is being tied up in the soil. This does not mean that the lead cannot become mobile again.

G101 was intended to be the upgradient well but it appears from the groundwater analysis data, for pollutants other than lead, to be affected by the waste pile. Therefore, another upgradient well north of the site is needed. This should be drilled and constructed in the same manner as the previous set of wells. Another boring south of the site taking frequent soil samples and having them analyzed for lead would help to confirm the present data from the initial boring and the speculation on the movement of the lead down through the soils.

## VIII) SURFACE WATER POLLUTION ASSESSMENT

### A) Taracorp

The IEPA's Division of Water Pollution Control has never issued Taracorp any permit. However, permits are required for the battery acid neutralization system and the oil skimmer in the Pipe Department. A permit application for the neutralization system was received on January 17, 1983, but was found to be incomplete. The application was denied on February 25, 1983.

In addition, Taracorp has not characterized the lead concentration of runoff from their property. This runoff enters the Granite City combined sewer system and may contribute to water pollution through overflows or through problems caused in the Granite City treatment plant. Although effluent from the treatment plant meets State requirements, the lead content of the sludge is among the highest in the State. This sludge is currently being disposed of in an approved landfill.

### B) St. Louis Lead Recyclers

St. Louis Lead Recyclers holds a State permit for its pretreatment facility. The discharge point appears to be in compliance with all applicable rules, and no additional discharge points are believed to exist.

However, the grounds of St. Louis Lead Recyclers (which are leased from Bank Trust 454) are extensively contaminated with lead. In addition, St. Louis Lead Recyclers has over 6,000 tons of processed hard rubber, contaminated with lead, piled outside.

## IX) LAND POLLUTION ASSESSMENT

### A) On-site

Taracorp maintains a waste pile of lead bearing scrap covering approximately three acres and containing about 200,000 tons of material. The degree to which this pile extends below ground is unknown. The analyses of samples taken from the pile indicate that these materials are high in lead content. Slag and matte generated from the blast furnace operations are still being deposited on the pile. Because of the high lead content of the material in the pile, further evaluation of potential health hazards is planned.

In addition, operations of St. Louis Lead Recyclers involve transferring large quantities of wastes from one location to another. In sorting the material to be recycled, slag, matte and trash are separated out and piled in the open.

The hard rubber generated from the recycling process was spread-out over the Bank Trust 454 property as ground cover during the summer of 1982. Excess rubber was placed in an outdoor storage pile. Because of the high lead content of the hard rubber, St. Louis Lead Recyclers took up the spreadout hard rubber and placed it on the storage pile to reduce leaching and reentrainment. Process changes have also been made to reduce residual lead.

Total soil-lead analyses were performed at several locations on the site grounds. Samples were taken near the rear gate area of Taracorp in August of 1982. These samples indicated that the soil contained 300,000 ppm (30 percent) lead. Subsequent to this finding, St. Louis Lead Recyclers removed the top few inches of soil (when they removed the hard rubber) and Taracorp applied gravel to the immediate area. Samples taken after this indicate that soil in the rear gate area still contains about 140,000 ppm lead. Samples taken on other portions of the Bank Trust 454 property indicate high lead levels in the soil. The results of this sampling are presented in Table IX-1, and the locations of the sampling points are shown in Figure IX-1.

Table IX-1. Soil-Lead Concentrations for On-Site Samples

<u>Sample</u>	<u>Concentration (ppm Lead)</u>	<u>Date of Sample</u>
A	12,000	(8/19/82)
B	75,000	(8/19/82)
C	300,000	(8/19/82)
D	300,000	(8/19/82)
E	5,100	(1/27/83)
F	86,000	(1/27/83)
G	140,000	(1/27/83)
H	48,000	(1/27/83)
I	67,000	(1/27/83)

#### B. Off-site

Soil samples were taken from neighborhoods in the vicinity of the smelter. Four types of samples were taken: "A", "B", "C", and "Garden". "A" and "B" samples were taken with a standard soil borer/auger, one inch in diameter. The sampler was rotated as it was pushed into the soil to prevent compression of the sample. Only the uppermost inch was removed from the core and placed in a container. No attempt was made to remove vegetation, but this was not used in the profile's dimension. This procedure was repeated three times to obtain a composite sample. Each sample was removed at a distance of no less than 10 feet from any other sample. Care was taken to select undisturbed soil and to avoid removing a sample within 10 feet of painted structures, former structures, waste piles, roadways, or painted playground equipment.

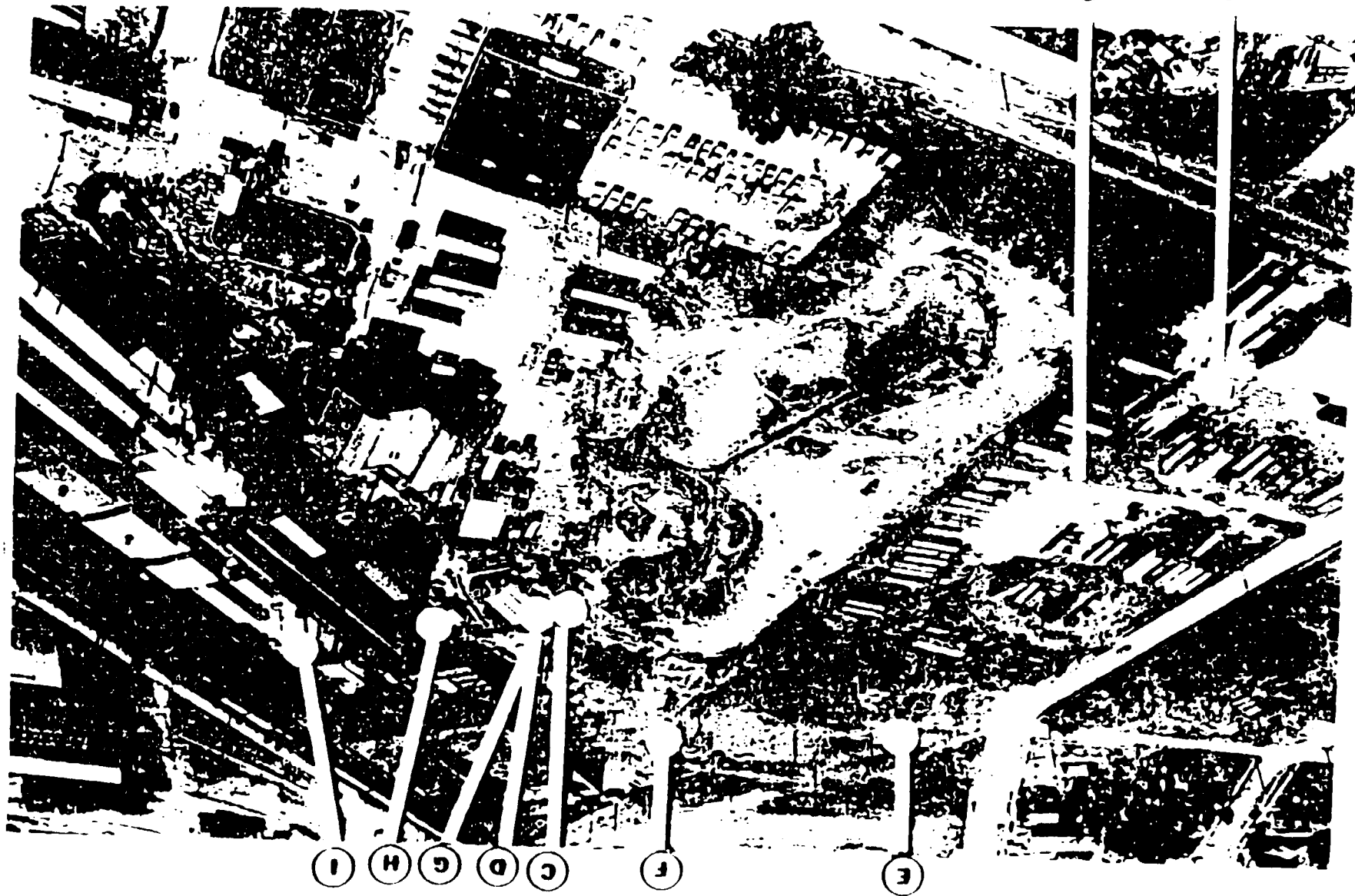


Figure IV-1. Location of the site surface soil samples.

Each sample type is discussed below:

"Soil A" - These samples were taken primarily to determine long term deposition patterns. The samples were taken from vegetated areas where the soil was unlikely to have been recently disturbed.

"Soil B" - These samples, which were intended to indicate levels to which children would most likely be exposed, were taken from open dirt areas in yards, playgrounds, etc. Samples were split between IEPA, IDPH and USEPA.

"Soil C" - These samples (2) were taken to determine the depth to which high lead levels may extend in the soil. The above protocol was used except that one nine-inch core was taken instead of three one-inch cores. The nine-inch core was divided into three, 3-inch sections for analysis.

"Garden" - As a part of the garden vegetable sampling program, soil samples were taken from each garden sampled. The samples were taken from the top three inches of soil with a spatula.

The results of "Soil A", "Soil B", "Garden" and the top three-inch section of "Soil C" samples are presented in Figure IX-2. It can be seen that the soil concentrations are generally highest in the immediate vicinity of the smelter and decrease with increasing distance. Using "Soil A" samples as the most reliable upper estimates of soil concentration (because they represent undisturbed soils) and recognizing that the other samples may underestimate typical surface soil concentrations, some rough lead concentration isopleths can be drawn. This has been done in Figure VI-7. The implication of these soil concentrations is discussed in the Hazard Assessment Section.

The "Soil B" values presented in Figure IX-2 are averages of values reported by IEPA, IDPH and USEPA. The agency-specific values are generally in good agreement, and provide confidence in the reliability of the laboratory results. The values are presented in Table IX-2.

Figure IX - 2: Surface Soil Sample Results (ppm Lead)

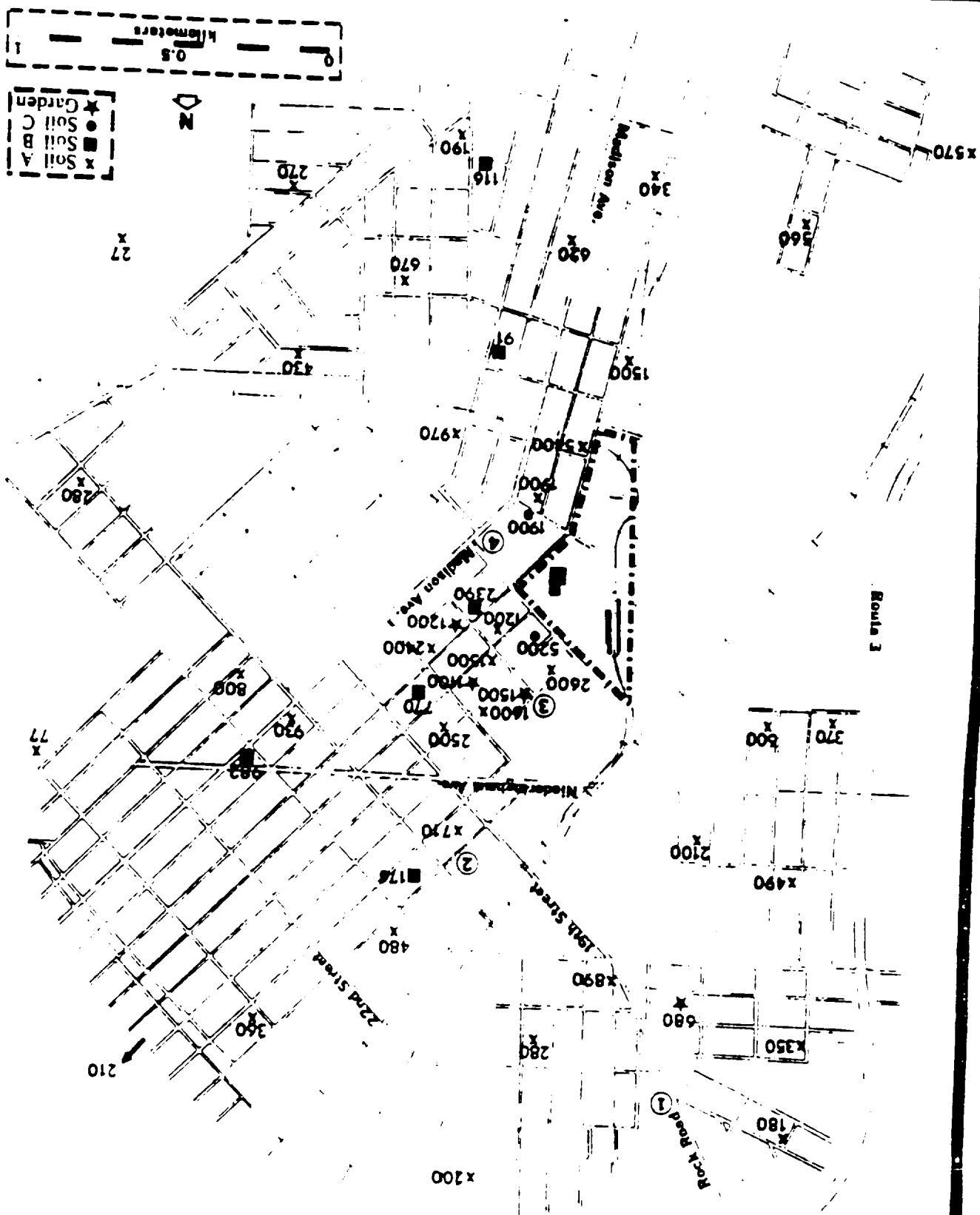


Table IX-2. Soil-Lead Concentrations for "Soil B" Samples (ppm)

<u>Sample Number</u>	<u>Avg.</u>	<u>EPA</u>	<u>IDPH</u>	<u>USEPA</u>
SB101	2390	2600	2860	1700
SB102	770	800	759	750
SB103	982	950	995	1000
SB104	176	200	159	170
SB105	51	59	44	49
SB201	116	120	108	120
SB202	91	120	76	76

"Soil C" sample results, presented in Table IX-3, demonstrate that lead contamination extends at least as far as nine inches below the surface.

Table IX-3. Soil-Lead Concentrations for "Soil C" Samples (ppm)

<u>Sample Number</u>	<u>0-3"</u>	<u>3-6"</u>	<u>6-9"</u>
SC101	5200	1300	290
SC201	1900	810	980

#### X ) HEALTH HAZARD ASSESSMENT

Through the use of environmental quality data, a rough estimate of human exposure to lead can be made. Comparing the exposure estimates to what is known about the toxicity of this substance, an estimate of the likely health effects can also be made.

In addition, attempts have been made to directly measure the extent of lead exposure in the population. This has been done by the Illinois Department of Public Health (IDPH) through a survey of blood-lead levels in the community. These measurements can aid in the overall assessment of the potential health hazard.

The hazard assessment is made by combining these factors. Exposure estimates can be compared to what is known about acceptable exposure levels; estimated blood-lead levels can be compared to acceptable blood-lead levels; and measured blood-lead and FEP levels can serve as direct checks on the estimates.

1) Routes of Exposure and Absorption

Inhalation

Lead can be absorbed into the bloodstream by inhaling airborne particulates containing lead. The rate of absorption depends on the particle size, the chemical species of lead, as well as factors specific to the individual. Although the relationship between ambient air lead concentrations and blood-lead concentrations varies considerably among individuals, nearly all studies have demonstrated ratios of 1:0.5 to 1:4.0 (ug/m<sup>3</sup> Pb to ug/dl Blood-Pb). Most studies report ratios of 1:1 to 1:2 (Ref. 1, pp 12-25, 12-29). Although USEPA has stated that no one ratio can accurately describe the air lead to blood lead ratio in all cases, one was selected by the USEPA as being representative of study results when the NAAQS for lead was proposed. The ratio was 1:2, indicating that a change in the ambient air lead concentration of 1 ug/m<sup>3</sup> results in a corresponding change of 2 ug lead per deciliter (dl) of blood (Ref. 3, p 41211).

Data cited in USEPA's Preliminary Draft Air Quality Criteria Document generally supports a linear relationship in the range of 1:1 to 1:4 for relatively low ambient concentrations (3.2 ug/m<sup>3</sup> or less) (Ref. 4, p. 13-27 to 13-29).

Oral Ingestion

The gastrointestinal tract is not as efficient in absorbing lead as the lungs. Absorption rates vary with a number of factors, including age, form of intake (food, soil, water, etc.), and nutritional factors. The chemical species of the lead may also be important. In general, adults will absorb 10-15 percent of ingested lead, but children may absorb up to 50 percent (Ref 1, p 10-2; Ref 4, p 13-5; Ref 6, p C-16).

Scientific studies have not developed a precise relationship between ingested lead and blood-lead levels. A general relationship of a 3-6 percent increase in blood-lead for a doubling of soil-lead concentrations has been noted in some studies (Ref 1, p 12-32). However, it is uncertain how much of this is due to inhalation and how much is due to ingestion. The relationship between blood-lead and soil-lead is discussed further in subsection X(C).

Food and water intake and its relationship to blood-lead is also unclear. Although a general relationship of 6 ug/dl blood-lead for every 100 ug of daily dietary lead intake is suggested by various studies, there are many variables determining this rate, and the rate for children is expected to be higher (Ref 1, p 10-4, p 12-32).

Maximum acceptable daily dietary intake for children has been estimated to be 300 ug/day, with only 150 ug/day allowed for children under age three, and only 100 ug/day for infants under six months (Ref 7, p 5).

## 2) Distribution and Elimination

Once lead has entered the blood stream it has a high affinity for bone deposition. Roughly 95 percent of the lead found in adults is contained in the bones (Ref 1, pg 10-5). However, only about 72 percent of the lead in children is in the bones. More is found in the soft tissues, increasing its availability for recirculation (Ref 5, p C--20).

Blood-lead concentrations generally level off after a few months of constant exposure. This does not represent a true equilibrium level, however, as elimination of lead following termination of exposure generally takes much longer when the exposure occurred over several years as opposed to several months (Ref 5, p C-20; Ref 6, p 417).

In adults, lead is eliminated primarily through the urine, with fecal elimination and loss of epithelial tissue being of secondary importance. In children, however, fecal elimination appears to predominate (Ref 5, p 418).

## 3) Biological Effects

Lead intoxication has been associated with severe neurological disorders such as profound retardation, tremors, and loss of memory. Coma and death, though rare, have occurred in some extreme cases. However, these problems occur at much higher dosages than would normally be expected from environmental pollution (Ref 6, p 418). Environmental exposures can cause more subtle toxic effects such as blood system dysfunction, psycho-neurologic dysfunction, kidney dysfunction, and reproductive impairment.

### Blood System Dysfunction

Anemia is presently considered to be the toxic effect occurring at the lowest excess blood-lead level. The anemia apparently can result from two separate effects of lead on the blood system (Ref 1, p 11-7 to 11-14). One effect is an increase in the fragility of the red blood cell membrane. The result is to decrease the average lifetime of red blood cells in the circulatory system.

The second effect is a reduction in the rate of synthesis of "heme", which is a molecule used to make the hemoglobin in red blood cells. The result is to decrease red blood cell production. One of the mechanisms by which this is believed to occur is the inhibition of a particular enzyme used in heme synthesis. Although inhibition of this enzyme occurs at blood-lead levels as low as 10 ug/dl, sufficient inhibition to significantly interfere with heme synthesis and result in anemia apparently does not occur until blood-lead levels of approximately 40 ug/dl. Thus, 40 ug/dl was considered a "threshold" level in the development of the NAAQS by the USEPA. However, USEPA designated 30 ug/dl as the maximum allowable level for children to provide an adequate margin of safety (Ref 2, p 46253).

Another result of enzyme inhibition in the heme synthesis process is the buildup of an organic chemical, protoporphyrin, in the erythrocytes, or red blood cells. Although not perfectly correlated with blood-lead levels, a test of erythrocyte protoporphyrin, or "EP", levels is often used as a screening technique for lead poisoning and is a better indicator of long-term (greater than 90-day) exposure.

#### Psycho-neurologic Dysfunction

Lead poisoning can cause profound psycho-neurological dysfunctions. Children appear to be the most susceptible portion of the population. Research has indicated that blood-lead levels as low as 50-60 ug/dl can cause significant psycho-neurological disorders (Ref 1, pp 11-18 to 11-26).

Since the publication of USEPA's 1977 Air Quality Criteria Document for Lead, many studies have been released on psycho-neurological effects at blood-lead levels of 30-40 mg/dl and below. The preliminary draft of the revised criteria document discusses these studies (Ref 4, pp 12-38 to 12-149). While some of the studies indicate significant impairment of performance skills due to lead exposure, the results cannot be considered conclusive because of methodological problems complicating their interpretation. The studies are receiving significant attention by USEPA in workshops being held on revisions to the criteria document.

### Kidney Dysfunction

A progressive, degenerative disease of the kidneys called chronic lead nephropathy has been reported in industrial workers exposed to lead, older adults having had lead poisoning as children, and long-term drinkers of illicit lead-contaminated whiskey (Ref 1, p 11-44). Numerous methodological problems in measuring the relationship between lead exposure and kidney dysfunction exist. However, lead-related kidney disease and associated problems such as gout and hypertension continue to be a serious concern and the subject of toxicological study.

### Reproductive Impairment

Lead readily crosses the placental barrier and may exert toxic effects directly on the conceptus or indirectly, through nutritional effects on the mother (Ref 1, p 11-46). Because of the relationship between lead exposure and reproductive impairment, women have generally been excluded from occupational environments containing lead.

Lead exposure has been associated with increased rates of stillbirth, miscarriage, premature membrane rupture and premature delivery (Ref 1, p 11-46).

While some evidence exists for teratogenic or mutagenic effects of lead, a direct association has not yet been established (Ref 1, p 1-47). Of particular concern, however, is the possibility of subtle, long-term behavioral or intelligence effects.

## 8) Exposure Estimates

### 1) Air

As shown in Section VI(A), Air Quality Monitoring, ambient lead concentrations have frequently exceeded  $2.0 \text{ ug/m}^3$ . This value as well as the NAAQS ( $1.5 \text{ ug/m}^3$ ) and  $1.0 \text{ ug/m}^3$  is used in evaluating a range of exposures in subsection XI(C) of this report.

### 2) Soil

In Section IX(B), Land Pollution Problems - Off-site, soil sample results indicating extensive lead contamination in area neighborhoods are discussed. One set of soil samples was taken from exposed dirt areas where children may play.

These samples were designated "Soil B" samples and were designed to estimate actual levels to which children may be exposed. It can be seen from the results in Figure IX-2 that "Soil B" levels are slightly lower but roughly consistent with other soil samples. To encompass the range of soil concentrations found in the area, values of 200, 1,000, and 5,000 ppm are used in this report for the health hazard analysis, although the highest "Soil B" (open dirt areas) value was 2,390 ppm.

In order to determine exposure, some estimate must be made concerning the amount of soil a child can ingest. In reviewing the literature for an assessment of contaminated soil in Minnesota, Dr. Mary Arneson concluded that a reasonable estimate of the range of intake rates for children would be 50 to 500 mg dust or soil per hour of play. Although the number of hours per day that a child plays in a dirt area varies considerably, it is not unreasonable to assume that up to 5 hours of exposure could occur each day for an extended period of time during the summer. Thus, 250 to 2,500 mg of soil could be consumed each day, recognizing that 2,500 mg/day is probably extreme. Dr. Arneson also noted that from 20 to 100 mg/day may be ingested by infants (Ref 7, p 7).

In a National Academy of Sciences study on lead, soil intake values of 100 mg/day for children without pica, and 1000 mg/day for children with pica are reported (Ref. 8, p. 58). Pica is a condition affecting many children in which there is an unusually strong need for placing objects in the mouth.

The table below provides daily lead intakes that would result from the range of soil intakes and soil concentrations discussed above.

Table X-1. Daily Lead Intake (ug)

<u>Daily Soil Intake (mg)</u>	<u>Soil Lead Concentrations (ppm)</u>		
	<u>200</u>	<u>1000</u>	<u>5000</u>
20	4	20	100
100	20	100	500
500	100	500	2500
1000	200	1000	5000
2500	500	2500	12,500

3) Food

The average daily intake of lead from food has been estimated at 100 ug/day for children 0-2 years old and 150 ug/day for children 2-3 years old (Ref 8, p 47). An estimate of 210 ug/day has been made for children 8.5 years old (Ref 5, p C-7). In this study, samples were taken of garden vegetables throughout the region and subsequently analyzed in a United States Food and Drug Administration laboratory. Table X-2 displays the results. The samples were taken in the Fall of 1982. The soil concentrations associated with each garden are listed, and are indicative of the area in which the garden is located; sites 4, 5 and 6 are from control areas on the northeast side of Granite City.

Table X-2. Lead Concentrations in Garden Samples (ppm - wet weight\*)

<u>Site #</u>	<u>Sample</u>	<u>Pb</u>
1	Peppers	0.119
	Tomatoes	0.122
	Banana Peppers	0.134
	Cauliflower (frozen)	0.198
	Soil	1500
2	Eggplant	0.048
	Tomatoes	0.066
	Okra	0.128
	Carrots	0.392
	Soil	1100
3	Tomatoes	0.035
	Cabbage	0.633
	Peppers	0.053
	Cucumber	0.083
	Soil	1200
4	Okra	0.020
	Banana Peppers	0.010
	Tomatoes	0.005
	Peas	0.002
	Soil	53
5**	Pepper	0.007
	Tomatoes	0.007
6	Okra	0.014
	Banana Peppers	0.010
	Soil	97
7	Tomatoes	0.028
	Squash	0.124
	Okra	0.641
	Beets	0.087
	Beet Leaves	0.058
	Soil	680

\* Soil values are based on dry weight

\*\* Site #5 is located across the street from Site #6. Therefore a separate soil sample was not taken.

Although lead concentrations vary considerably depending on the type of vegetable, it can generally be concluded that vegetables in the contaminated region contain from 0.05-0.5 ppm lead and vegetables in control regions contain from 0.005 to 0.05 ppm lead on a wet weight basis.

Assuming that 10 to 100 g/day (based on a total diet of 1000 g/day) of garden vegetables may be consumed for an extended period of time by children, daily lead intake estimates may be increased by 0.5-5 to 5-50 ug/day.

Except for the high end of these estimates, they do not represent a major portion of the daily dietary intakes discussed above. Gardens in the vicinity of the smelter were generally small and were not believed to produce a large quantity of vegetables. In addition, only a few samples (carrots, cabbage, and okra) demonstrated lead levels higher than 0.2 ppm. Considering both these factors, it would be extremely unlikely that a child would consume 100 g/day of a vegetable containing 0.5 ppm lead each day for 30 to 90 consecutive days. A more reasonable estimate would be that vegetables consumed over such a period of time would be closer to an average of 0.1 ppm lead. This would mean an intake of 1 to 10 ug/day from garden vegetables.

Soil cation exchange capacity and pH are the two largest factors determining lead uptake by plants. Assuring near neutral pH and normal cation exchange capacity will minimize lead uptake. However, significantly altering soil cation exchange capacity is often difficult. Phosphate and pH levels appropriate for optimal garden productivity will aid in reducing lead uptake.

#### 4) Water

Drinking water in the community is taken from the Mississippi River. The lead concentration is less than the State drinking water standard of 0.05 ppm and most samples are below the laboratory detection limit of 0.005 ppm. Thus, present data indicates that exposure from drinking water is not abnormal.

#### 5) Other

There are many other sources of lead exposure for children. One of the major sources can be consumption of lead-based paint chips in the home. Exposure through the work or hobbies of others in the family is also important. Many of these potential exposure sources were investigated through a questionnaire administered to residents in the area by IDPH in connection with their blood-lead survey. These other exposure sources were not found to be major based upon a preliminary analysis of the survey results.

C) Estimate of Blood-lead Levels

Much of the available toxicological data relates adverse effects to various concentrations of lead in the blood. Thus, estimating blood-lead concentrations resulting from environmental exposure is an important part of a health hazard assessment. Although much of the data is still preliminary, a rough estimate of potential health hazard can be made.

USEPA, in developing the National Ambient Air Quality Standard for lead, estimated a background blood-lead concentration from non-air sources of 12 ug/dl (Ref. 1, p 46254). Using this number, total blood-lead can be estimated by adding the contributions from airborne lead and other sources having concentrations higher than the background level.

1) Air

Based on a review of studies documenting the relationship between air-lead and blood-lead concentrations, USEPA concluded that the best estimate was 1:2; that is, every 1 ug/m<sup>3</sup> increase in air-lead concentrations results in an increase of 2 ug/dl in blood-lead. They note, however, that a range appears to exist, and that the ratio may be more severe for children and more severe at lower air-lead concentrations (Ref 2, p 46250; Ref 1, p 12-24 to 12-29). The 1:2 ratio is used for this analysis.

Table XI-3 provides estimates of the increase in blood-lead concentrations that would result from the range of air-lead concentrations under study assuming the 1:2 air/blood relationship.

Table X-3. Increases in Blood-Lead Due to Various Air-Lead Concentrations

<u>Ambient Air-Lead</u> <u>Concentration (ug/m3)</u>	<u>Increase in</u> <u>Blood-Lead (ug/dl)</u>
1.0	2.0
1.5	3.0
2.0	4.0
7.3	14.6

## 2) Soil

National background soil concentrations of lead have been documented as 10-30 ppm (Ref 5, p C-2; Ref 8, p 156). Although soil-lead concentrations associated with the development of the 12 ug/dl background blood-lead level are not known, it is reasonable to assume that the soil lead concentrations in the vicinity of the smelter (200 - 5000 ppm) almost entirely represent contamination above background.

In the Preliminary Draft of the revised Criteria Document, USEPA cites a study from which soil/blood relationships have been derived for children 1-3 and 6 years of age (Ref 4, p 11-94). They report an increase above background of  $0.0076 \times \text{soil-lead (ppm)}$  for children 1-3 years old, and  $0.0046 \times \text{soil-lead (ppm)}$  for children 6 years old. Based upon these relationships, Table X-4 provides blood-lead estimates for each age group, over various soil concentrations, assuming that the  $0.0046 \times \text{soil ppm}$  can be applied to all children over three years old.

Table X-4 Increases in Blood-lead Concentrations from  
Soil Ingestion (ug/dl)

<u>Soil Conc. (ppm)</u>	<u>Children 0-3 yrs old</u>	<u>Children over 3 yrs old</u>
100	0.76	0.46
200	1.52	0.92
500	3.80	2.30
1000	7.60	4.60
2000	15.20	9.20
5000	38.00	23.00

Several qualifications should be noted at this point. First, the above formulas are presented in a draft document that has not yet been released for general review. Thus, they are subject to change and cannot be considered to reflect a final USEPA position. Second, the background blood-lead levels found in the above study, and other studies, have generally been higher than the 12 ug/dl used in this analysis. However, the Granite City-Madison-Venice area has not been associated with high blood-lead levels from consumption of paint chips or other sources based upon earlier blood-lead screening work. It must be recognized that there is considerable uncertainty in selecting the appropriate background level and soil-lead/blood-lead relationship.

Angle et. al. (1983) have also reported a linear relationship between blood-lead and other variables, including soil concentration (Ref. 9, p. 6). They report an increase of 0.00681 ug/dl for each ppm soil concentration for children 1-18 years old. This is roughly consistent with the values reported above by USEPA.

3) Diet

Because food and water exposure were found to be unlikely to pose a significant increase in lead intake, it will be assumed that no contribution to blood-lead beyond background will occur.

4) Other

Household exposures were not found to be significant and are therefore assumed not to affect blood-lead levels based upon preliminary findings of the blood-lead survey.

5) Overall Estimate

To estimate the overall blood-lead levels, the effects of both air and soil exposure must be combined. Since air quality modeling results are not yet complete, a precise relationship between air concentrations and soil concentrations cannot yet be delineated. Thus, it is assumed for this analysis that any air quality level can occur in conjunction with any soil quality level. However, the association of high air with high soil lead as well as low air with low soil lead is likely.

For the overall estimate, the soil/blood relationships presented in Table X-4 were used. These values were added to the blood-lead values from air exposure (Table X-3) and the background value of 12 ug/dl to derive the overall estimates in Table X-5. It should be noted that these are estimates of the population mean. Table X-6 presents similar results for children over 3 years of age.

As discussed in subsection (A) above, Toxicity of Lead, USEPA selected a level of 30 ug/dl in setting the National Ambient Air Quality Standard (NAAQS) to provide a sufficient margin of safety for children. Given the natural variation in blood-lead levels, and USEPA's goal of keeping all but 0.5 percent of the exposed children below the 30 ug/dl level, a population mean blood-lead level of 15 ug/dl was selected. (It should be noted, however, that approximately five percent of children exceed 30 ug/dl as a national average). This is based on evidence that blood-lead concentrations are lognormally distributed over a population with a standard geometric deviation (SGD) of 1.3. Higher and lower SGD's have been measured, but 1.3 was selected by USEPA.

Table X-5 Overall Mean Blood-lead Level Estimates for  
Children 0-3 yrs Old

Soil Concentration (ppm)	Air Quality (ug/m <sup>3</sup> )		
	<u>1.0</u>	<u>1.5</u>	<u>2.0</u>
100	14.76	15.76	16.76
200	15.52	16.52	17.52
500	17.80	18.80	19.80
1000	21.60	22.60	23.60
2000	29.20	30.20	31.20
5000	52.00	53.00	54.00

Table X-6 Overall Mean Blood-lead Level Estimates for  
Children Over 3 yrs Old

Soil Concentration (ppm)	Air Quality (ug/m <sup>3</sup> )		
	<u>1.0</u>	<u>1.5</u>	<u>2.0</u>
100	14.46	15.46	16.46
200	14.92	15.92	16.92
500	16.30	17.30	18.30
1000	18.60	19.60	20.60
2000	23.20	24.20	25.20
5000	37.00	38.00	39.00

As individual child blood-lead concentrations increase above the margin-of-safety level of 30 ug/dl, there is increasing likelihood of toxic effects. At an individual blood-lead level of 40 ug/dl, anemia has been well documented. Thus, toxic effects are likely above this value. As the population mean value increases from 15 ug/dl, an increasing percentage of the population is expected to exceed 30 and 40 ug/dl. To better illustrate the potential hazard, Tables X-7 through X-10 were constructed to show the percentage of the childhood population exceeding 30 and 40 ug/dl based on the mean levels presented in Tables X-5 and X-6. These values were calculated assuming an SGD of 1.3.

Table X-7 Percent of Children 0-3 Yrs Old with Blood-lead Levels Above 30 ug/dl

Soil Concentration (ppm)	Air Quality (ug/m <sup>3</sup> )		
	<u>1.0</u>	<u>1.5</u>	<u>2.0</u>
100	0.5	0.7	1.3
200	0.6	1.2	2.0
500	2.3	3.8	5.7
1000	10.6	14.0	18.1
2000	46.02	51.20	55.96
5000	98.20	98.50	98.75

Table X-8 Percent of Children Over 3 Yrs Old with Blood-lead Levels over 30 ug/dl

Soil Concentration (ppm)	Air Quality (ug/m <sup>3</sup> )		
	<u>1.0</u>	<u>1.5</u>	<u>2.0</u>
100	0.3	0.6	1.1
200	0.4	0.8	1.5
500	1.0	1.8	3.0
1000	3.4	5.3	7.6
2000	16.4	20.6	25.5
5000	78.8	81.6	84.1

Table X-9 Percent of Children 0-3 Yrs Old with Blood-lead Levels Above 40 ug/dl

Soil Concentration (ppm)	Air Quality (ug/m <sup>3</sup> )		
	1.0	1.5	2.0
100	0.0	0.0	0.0
200	0.0	0.0	0.1
500	0.1	0.2	0.4
1000	0.9	1.5	2.2
2000	11.5	14.2	11.1
5000	84.1	85.8	87.3

Table X-10 Percent of Children Over 3 Yrs Old with Blood-lead Levels over 40 Ug/dl

Soil Concentration (ppm)	Air Quality (ug/m <sup>3</sup> )		
	1.0	1.5	2.0
100	0.0	0.0	0.0
200	0.0	0.0	0.0
500	0.0	0.0	0.1
1000	0.2	0.3	0.6
2000	1.9	2.7	3.9
5000	23.6	42.1	48.0

It can be seen from Tables X-5 and X-6 that, even for air quality levels under 2.0 mg/m<sup>3</sup> air quality, the percentage of children exceeding 30 mg/dl is far above USEPA's target of 0.5 percent, and significantly above the national average of 5 percent at higher soil levels. Note also that in areas of soil concentrations as high as 2000 to 5000 ppm, a substantial percentage of the children would exceed even the 40 ug/dl.

If the NAAQS of 1.5 ug/m<sup>3</sup> were attained in the area, over 5 percent of the children would still exceed the margin-of-safety level of 30 ug/dl unless soils were reduced to less than 1000 ppm. Tables X-7 and X-8 illustrate that even if ambient air concentrations could be reduced to 1.0 ug/m<sup>3</sup>, 33 percent below the standard, soil concentrations of 1000 ppm or higher might still cause a significant percentage of the children to exceed the margin-of-safety level of 30 ug/dl. It should also be noted, based on the information in Tables X-9 and X-10, that in areas of high soil concentration, a significant percentage of the children could exceed 40 ug/m<sup>3</sup>. This clearly illustrates the difficulty in determining an acceptable concentration of lead in one medium (e.g., air) because of uncertainty with respect to exposure through other media (e.g., soil).

Although recent ambient lead air quality levels have been well below the 7.3 mg/m<sup>3</sup> peak reported for the fourth quarter at 1981, exposures during that time could have placed more than one-third of the children over 30 ug/dl in areas where soil-lead levels exceed 200 ppm, and more than 10 percent of the children over 40 mg/dl in areas where soil-lead levels exceed 500 ppm.

01) IDPH Blood-lead Survey

To help assess the hazard posed by lead contamination in Granite City, the Illinois Department of Public Health (IDPH) conducted a survey of blood-lead concentrations. The survey consisted of three parts. The first part was a questionnaire concerning the household and its members. It was used to help identify sources of lead exposure. Secondly, each house where blood samples were taken was examined for lead paint and other sources of lead contamination. The third part of the survey was comprised of data on each individual, particularly the resulting blood-lead and FEP levels. FEP (free erythrocyte protoporphyrin) is an enzyme whose release in the blood is directly proportional to lead exposure.

The survey was administered during the fourth quarter of 1982. Statistical analysis of the results took considerable time because of the necessity for lab work and data entry to the computer system. A complete statistical analysis of the numerous variables included in the questionnaire is expected within the next two months. However, preliminary results are available.

Several problems were anticipated with respect to obtaining complete survey information. One was obtaining the full cooperation of residents. Because of competing priorities in many family situations, the limited State resources that could be devoted to gaining cooperation, and the relatively short time frame within which the work had to be completed, it was anticipated that some public resistance might be encountered. Unfortunately, this was the case and surveys were completed for only 43 households (97 individuals, with 46 being six years old or less).

Another complication was the slowdown of activity at the smelter. Monitoring data for the period of the blood-lead survey (see Air Quality Monitoring Section) showed that outdoor air quality was much better than normal. Also, exposure to soil-lead was substantially reduced compared to the summer.

The preliminary results of the survey indicate that excessive blood-lead levels and FEP levels were not present in the sampled population. IDPH considers a blood-lead level of 30 ug/dl or more, in conjunction with an FEP level of 50 mg/dl or greater to be "undue lead absorption", that is, a dangerously high level of lead absorption. No such cases were found, even though one or two could have normally occurred in a sample of 46 urban children.

In addition, the low FEP values (indicative of longer-term lead exposures of several months to a year) indicate that significant lead exposure has not been occurring for the sampled individuals as a whole.

Numerous factors relating potential household exposures to blood-lead and FEP indicate that such exposures are not significantly above normal.

However, the small number of people willing to participate in the study limits the extent to which these conclusions can be extrapolated to the rest of the population in the area. Thus, no significant lead exposure problems were found in the survey of residents in the vicinity of the lead smelter, but the lack of citizen participation (which resulted in a relatively small sample size) and, to some extent, the timing of the sampling effort, means that some uncertainty remains with regard to a possible health hazard. The results, however, are consistent with previous blood-lead screening work done in 1976 and 1979.

#### E) Hazard Assessment

The public health hazard posed by lead contamination is based not only on the toxicity of lead, but also on the level of environmental contamination and the extent to which people, particularly children, are exposed to these levels.

The public is exposed to lead in the vicinity of the smelter primarily through three means: air, soil, and garden vegetables. Each will be discussed in turn, and then they will be combined with data from the blood-lead survey to produce an overall hazard assessment.

### Air

Ambient air quality lead levels during 1982 were below 2.0 ug/m<sup>3</sup>. Levels have been repeatedly monitored at levels exceeding the NAAQS (1.5 ug/m<sup>3</sup>) have been monitored over the past four years, with a high of 7.3 ug/m<sup>3</sup> during the fourth quarter of 1981.

The potential for actual exposure of children to monitored ambient lead levels is greatest during the summer months when they spend a great deal of time outdoors. Thus, high ambient levels during the winter months should be less harmful than similar levels during the summer. Fortunately, the 1981 peak value of 7.3 ug/m<sup>3</sup> occurred in the Fall.

The NAAQS was based on the assumption that blood-lead due to air exposure would be added to a normal background blood-lead concentration of 12 ug/dl, and that exposures to more than 1.5 ug/m<sup>3</sup> would place a significant portion of the exposed children above the 30 ug/m<sup>3</sup> danger level. Thus, although ambient concentrations in 1982 were below 2.0 ug/m<sup>3</sup>, levels above 1.5 ug/m<sup>3</sup> should be considered a potential health hazard. Significant exposures from other sources, such as soil, will aggravate the effect of air exposure.

### Soil

The soil-lead concentrations found in the study area are significantly above background levels, particularly in Granite City. Levels as high as 2000 ppm are common in the inner-city portions of many urban areas such as Cincinnati, Ohio (Ref. 10) and Morton Grove, Illinois (Ref. 11). In other studies of residential areas surrounding smelters, values of 100-4000 ppm have been found in E. Helena, Montana (Ref. 4); 20-1,100 ppm in the Netherlands (Ref. 12); 20-4,800 ppm in Omaha, Nebraska (Ref. 3); 560-11,450 ppm in El Paso, Texas (Ref. 19), and 50-24,600 ppm in Silver Valley, Idaho (Ref. 15).

When a case of undue lead absorption is found in a child by the Illinois Department of Public Health, soil levels around the residence are required to be reduced to 200 ppm as a part of an overall plan to reduce lead exposure for that child to a minimum.

Figure X-1 in the exposure section provided estimates of lead intake given various soil-lead concentrations, and various assumptions regarding daily soil ingestion. A daily soil intake of 0.1 g/day was used as a rough estimate for normal consumption by a child, and 1.0 g/day for a child with pica.

A maximum tolerated intake of lead for children 0.5-3 years old has been estimated at approximately 150 ug/day. This value is for daily intake from all sources. Most of this amount is ingested daily from normal diet, and very little from soil.

Based on Figure X-1, it can be seen that a substantial portion (100 ug/day) of the maximum tolerated daily intake of lead for normal children could be obtained from the soil in areas with concentrations over 1000 ppm. Although the USFDA maximum tolerated daily intake level is not related directly to a particular blood-lead level or toxic effect, exceeding the recommended level by 100 percent or more could generally be considered a hazard.

Estimates of blood-lead levels indicate that soil-lead concentrations over 1000 ppm may place a significant percentage of children at risk. In addition, consultation with others knowledgeable in the field indicates a general consensus that soil-lead values of 1000-5000 ppm may be cause for concern (Ref. 16).

#### Garden Vegetables

Extended daily intakes of one to 10 ug/day from garden vegetables was estimated in the exposure section of this report. Compared to the 150 ug/day maximum tolerated daily intake limit, the contribution from eating garden vegetables grown in the area around the smelter appears to be minor.

However, this assessment is based on several assumptions. First, it is assumed that vegetables comprise no more than 10 percent of the diet by weight. Second, it is assumed that the amount of vegetables consumed over a period of 30 to 90 days is not primarily composed of root or leafy vegetables. Third, and most importantly, it is assumed that all vegetables are thoroughly washed. Eating unwashed leafy or root vegetables could greatly increase lead ingestion.

#### Overall Assessment

The preceding assessments, based upon results of studies in other areas, indicate that both air and soil concentrations found in the Granite City-Madison-Venice area could represent a health hazard. Garden vegetables grown in the vicinity of the smelter do not appear to pose a significant risk as long as they are thoroughly washed before eating.

Estimates made of blood-lead levels and the percentage of children exceeding 30 and 40 ug/dl (see Figures X-7 through X-10) indicate that soil concentrations over 1000 ppm, and especially over 2000 ppm, could pose a significant hazard, even if the NAAQS is attained in the area.

Preliminary findings from the IDPH blood-lead screening, however, indicate that unusually high blood-lead levels are not present. This may be partially explained by the fact that the samples were taken during November and December of 1982, when children were not spending many hours playing outdoors, and air quality levels were at or below the NAAQS. The fact that FEP blood values were not above acceptable levels indicates that exposure to lead during the preceding months to one year had not been unusually high.

The indication that high absorption of lead in the blood is not occurring is supported by a survey performed in September 1976 by the Illinois Association for Retarded Citizens, in which 4.5 percent, or about the national average, of the children in East Alton, Granite City, and Madison were found to have elevated blood-lead levels. Also supporting this conclusion are the results of a 1979 blood-lead screening of the area by the IDPH which indicate no unusual incidence of elevated blood-lead levels.

Thus, although significant environmental contamination exists in the vicinity of the smelter, and evaluation of the data collected must continue, the preliminary assessment is that a major risk to public health is unlikely to exist provided that ambient air quality levels do not exceed the NAAQS and that routine personal health and hygiene measures are followed.

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TB:jd/6536C/1-41/sp



ILLINOIS DEPARTMENT OF PUBLIC HEALTH

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M E M O R A N D U M

Reply to:

TO: Gareth R. Johnson, Program Administrator  
Childhood Lead Poisoning Control Program

FROM: Mildred Fort, Project Area Coordinator w/  
Madison/St. Clair Counties Lead Project

DATE: December 27, 1983

SUBJECT: IEPA/IDPH Blood Lead Survey

This memo is to inform you of the close out of the IEPA/IDPH Blood Lead Survey in the city of Venice, Illinois.

There were a total of 136 people tested. There were 134 screened during the period November 14, 1983 through November 30, 1983, by door-to-door canvassing and two adults living in the target area came into the clinic for testing the week of November 7, 1983. There were 48 children screened during the survey and 88 adults.

There were 171 households visited, testing was done in 67 of these households. There were 9 households which refused to participate in the survey. The most refusals were encountered on the first day and the last day of our survey. On November 14, 1983, the reason given for refusal was that they did not believe lead poisoning to be a problem there because they had lived there over 20 years and never had any ill effects. On the final day of the study, November 30, 1983, the reason given for refusal was that according to the news media there was no lead poisoning effects from the battery casings in their community, and they saw no reason to be screened. There were also a large number (95) of households where there was no one home.

The study areas were not areas with a lot of children. There were only 24 households of the 67 tested with children under six years old. The survey did not yield any elevated blood lead levels although some elevated EP levels were found.

The results of the survey are as follows:

11/5/84 -  
Cancer to Mary Lick &  
Tom B. same for date



I. Children - 48 tested

EP

<u>Range</u>	<u># of people</u>
16-20	2
21-25	13
26-30	15
31-35	13
36-40	2
41-45	0
46-50	2
51-55	0
56-60	1

BLOOD LEAD

<u>Range</u>	<u># of people</u>
0-5	11
6-10	24
11-15	9
16-20	2
21-25	0
26-30	1
QNS	1

II. Adults - 88 tested

EP

<u>Range</u>	<u># of people</u>
16-20	4
21-25	8
26-30	20
31-35	23
36-40	20
41-45	5
46-50	5
51-55	1
56-60	0
61-65	1
66-70	0
71-75	0
76-80	1

BLOOD LEAD

<u>Range</u>	<u># of people</u>
0-5	15
6-10	48
11-15	9
16-20	3
QNS	13

MF:cc

cc: George Rudis



# ILLINOIS DEPARTMENT OF PUBLIC HEALTH

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## M E M O R A N D U M

Reply to:

TO: Gareth Johnson, Administrator  
Childhood Lead Poisoning Control Program

FROM: Mildred Fort, Project Area Coordinator  
Madison/St. Clair Counties Lead Project

DATE: December 5, 1983

SUBJECT: Weekly Report of IEPA/IDPH Blood Lead Survey  
Week of November 28, 1983

Test results on samples drawn during door-to-door canvassing in  
Venice target area November 28, and 30, 1983.

### I. Children - 5 tested

#### EP RESULTS

<u>Range</u>	<u># of people</u>
16-20	0
21-25	1
26-30	1
31-35	1
36-40	1
41-45	0
46-50	1

#### BLOOD LEAD RESULTS

<u>Range</u>	<u># of people</u>
0-5	2
6-10	1
11-15	1
16-20	0
21-25	0
26-30	1

### II. Adults - 6 tested

#### EP RESULTS

<u>Range</u>	<u># of people</u>
16-20	1
21-25	0
26-30	0
31-35	0
36-40	2
41-45	1
46-50	1
51-55	0
56-60	0
61-65	1

#### BLOOD LEAD RESULTS

<u>Range</u>	<u># of people</u>
0-5	4
6-10	2

MF:cc

cc: George Rudis





# ILLINOIS DEPARTMENT OF PUBLIC HEALTH

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## MEMORANDUM

Reply to:

TO: Gareth Johnson, Administrator  
Childhood Lead Poisoning Control Program

FROM: Mildred Fort, Project Area Coordinator *mf*  
Madison/St. Clair Counties Lead Project

DATE: November 30, 1983

SUBJECT: Weekly Report of IEPA/IDPH Survey  
Week of November 21, 1983

During the week of November 21, 1983, limited IEPA/IDPH screening was done. Due to the short work week, it was necessary to complete some of our routine screening activities earlier in the week.

The results of samples drawn during the week were as follows:

### I. Children - 10 tested

#### EP RESULTS

<u>Range</u>	<u># of people</u>
21-25	4
26-30	5
31-35	1

#### BLOOD LEAD RESULTS

<u>Range</u>	<u># of people</u>
0-5	2
6-10	2
11-15	4
QNS	2

### II. Adults - 17 tested

#### EP RESULTS

<u>Range</u>	<u># of people</u>
21-25	1
26-30	5
31-35	8
36-40	3

#### BLOOD LEAD RESULTS

<u>Range</u>	<u># of people</u>
0-5	0
6-10	9
11-15	3
16-20	2
QNS	3

MF:cc

cc: George Rudis





# ILLINOIS DEPARTMENT OF PUBLIC HEALTH

William L. Kempiners, Director



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## M E M O R A N D U M

TO: Gareth Johnson, Administrator  
Childhood Lead Poisoning Control Program

FROM: Mildred Fort, Project Coordinator *mf*  
Madison/St. Clair Counties Lead Project

DATE: November 28, 1983

SUBJECT: Weekly Report of IEPA/IDPH Blood Lead Survey  
Week of November 14, 1983 - Part II

Test results on samples drawn during door-to-door canvassing in the Venice target area November 16, 17, 18, 1983.

### I. Children - 26 Tested

#### EP RESULTS

<u>Range</u>	<u># of people</u>
16-20	2
21-25	6
26-30	8
31-35	9
36-40	1

#### BLOOD LEAD RESULTS

<u>Range</u>	<u># of people</u>
0-5	6
6-10	18
11-15	1
16-20	0
QNS	1

### II. Adults - 42 Tested

#### EP RESULTS

<u>Range</u>	<u># of people</u>
16-20	1
21-25	5
26-30	10
31-35	9
36-40	10
41-45	2
46-50	3
51-55	1
76-80	1

#### BLOOD LEAD RESULTS

<u>Range</u>	<u># of people</u>
0-5	5
6-10	25
11-15	6
16-20	1
QNS	5

MF: cc

cc: George Rudis





# ILLINOIS DEPARTMENT OF PUBLIC HEALTH

William L. Kempiners, Director



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## M E M O R A N D U M

TO: Gareth Johnson, Administrator  
Childhood Lead Poisoning Control Program

FROM: Mildred Fort, Project Coordinator *mf*  
Madison/St. Clair Counties Project

DATE: November 21, 1983

SUBJECT: Weekly Report of IEPA/IDPH Blood Lead Study  
Week of November 14, 1983 - Part I

There were two adults who came into the clinic on November 10, 1983 prior to the actual canvassing. Both adults live in the target area of Venice. EP Results were in the 21-25 and 26-30 range. Blood Lead Results were in the 6-10 range.

Test results on samples drawn during door-to-door canvassing in the Venice target area November 14 & 15, 1983.

### I. Children - 7 tested

#### EP RESULTS

<u>Range</u>	<u># of people</u>
21-25	2
26-30	1
31-35	2
36-40	0
41-45	0
46-50	1
51-55	0
56-60	1

#### BLOOD LEAD RESULTS

<u>Range</u>	<u># of people</u>
0- 5	1
6-10	3
11-15	3

### II. Adults - 21 tested

#### EP RESULTS

<u>Range</u>	<u># of people</u>
16-20	2
21-25	1
26-30	4
31-35	6
36-40	5
41-45	2
46-50	1

#### BLOOD LEAD RESULTS

<u>Range</u>	<u># of people</u>
0- 5	6
6-10	10
11-15	0
QNS	5



This summary accounts for a total of 30 screenings during the period of November 10-15, 1983, blood lead results for the remainder of the week have not been received yet.

MF:cc

cc: George Rudis

EXHIBIT E



H.J. Conlon, M.D.  
L.A. Saryan, Ph.D.

# INDUSTRIAL TOXICOLOGY LABORATORY

WEST ALLIS

MEMORIAL

HOSPITAL

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## INTERPRETATION OF BLOOD LEAD DETERMINATIONS

We are frequently asked to provide "normal" or reference range values for lead determinations. Considering that lead is a toxic metal with no known human biochemical function, it is difficult to sustain that any amount of lead in biological fluids is a desirable situation. Nevertheless, all of us are subject to a small amount of lead in the environment which is not thought to be harmful at the levels ordinarily encountered.

An extensive survey of blood lead concentration in the American population was reported by Food and Drug Administration scientists in 1982 (1). Approximately 10,000 people were sampled by the low contamination venipuncture method. Blood lead concentrations were presented according to age, sex, and racial origin. The averages for all groups fell within the range of approximately 10-20 mcg/dl. These values correlate well with the experience of this laboratory. Blood levels of up to 20 mcg Pb/dl of whole blood reflect the environmental exposure of otherwise unexposed individuals.

In children, the CDC now states that levels of 25 mcg/dl or more are cause for concern, and immediate followup to remove the source of exposure is indicated (2). Medical intervention may be required in some cases.

Adults can tolerate larger amounts of lead without ill effects. As of September 1, 1983, the OSHA Lead Standard medical removal provision requires that exposed workers whose three-test average (or average of all tests in a six month period) is at or above 53 mcg/dl (50 mcg/100 g) be removed from exposure until the blood lead has decreased to 42 mcg/dl (40 mcg/100 g) (3). There are exceptions to these provisions for some industries. The OSHA Standard is based on current medical opinion that levels up to 40 mcg/dl pose no particular hazard to most adult individuals. Blood lead levels exceeding 70 mcg/dl are frequently associated with classical symptoms of lead toxicity (4).

Urine lead levels of up to 50 mcg/24 hrs. are observed in the absence of specific exposure.

### References:

- (1) Mahaffey, KR et. al. New England Journal of Medicine 307: 547-579, 1982.
- (2) CDC. Preventing Lead Poisoning in Young Children, January 1985.
- (3) OSHA. List of Laboratories Approved for Blood Lead Analysis. September 1983.
- (4) Lauwerys, RR. Industrial Chemical Exposure, 1983, pp. 27-38.

LAS/da 7-86

EXHIBIT F

# HISTORICAL SOIL BORING INFORMATION

ADAPTED FROM "RECORD OF SOIL TEST ON PROPOSED SITE OF WHITE LEAD BUILDING, UNITED LEAD CO., GRANITE CITY, ILLINOIS"

APPROXIMATE DATE - 1904

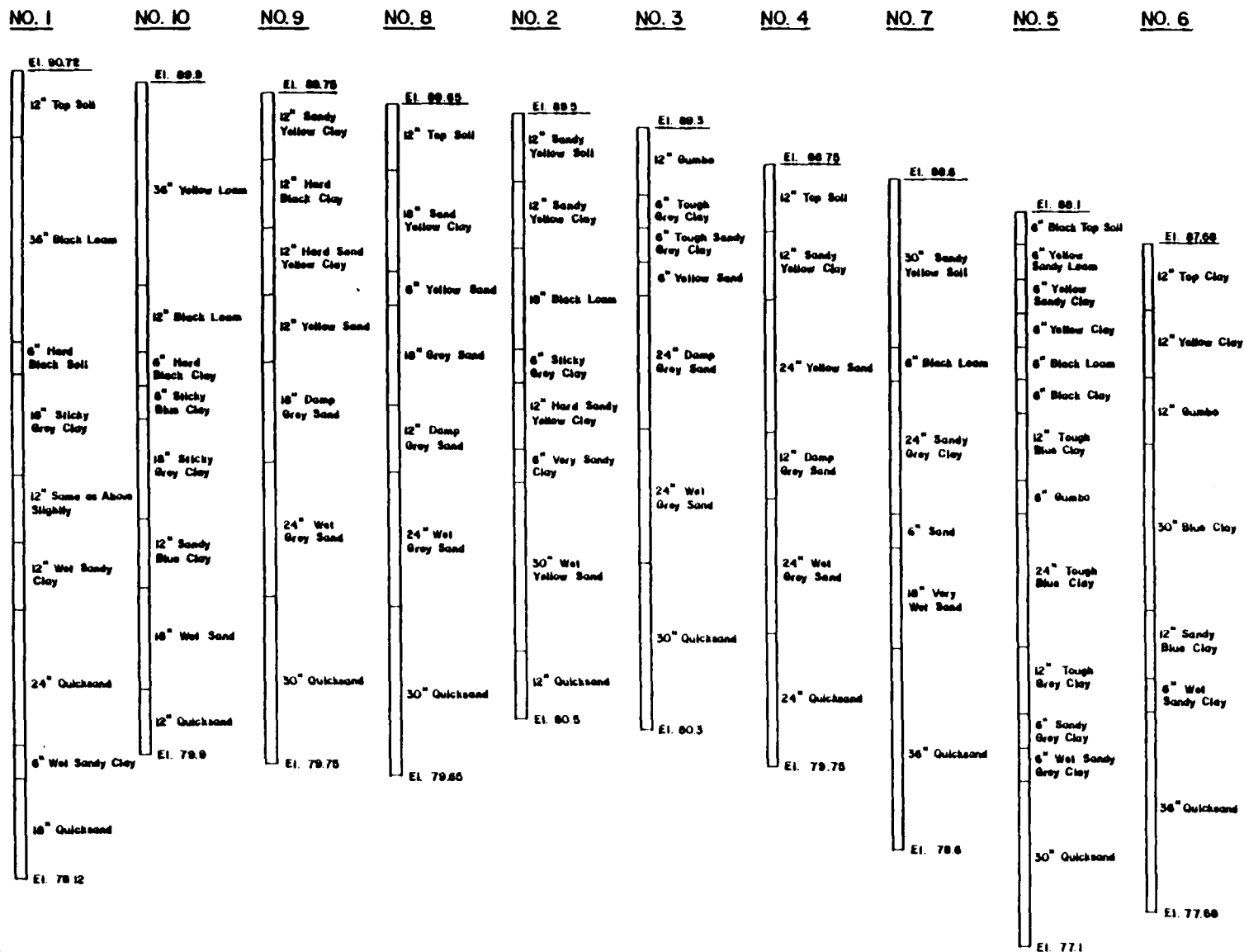


FIGURE 2

NL INDUSTRIES, INC  
GRANITE CITY SITE  
GRANITE CITY, ILLINOIS

**LEWIS**

- APPROPRIATE LIMITS OF CLASS FILE

1997's *Legend of the Blue Sea* and *Cherry Pop* from 2000.

**2014**

**G**ORDON & GORE